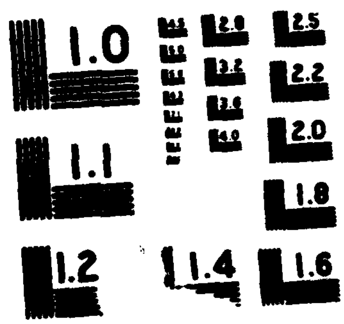
AD-A194 210 COMPUTER-AIDED DECISION MAKING(U) AIR COMMAND AND STAFF COLL MAXWELL AFB AL M D DUTILLY ET AL APR 88 ACSC-88-0810 1/2

UNCLASSIFIED F/G 12/5 NL


1.0
2.5
2.2
2.0
1.1
1.8
1.2
1.4
1.6

DTIC FILE COPY

(2)

AD-A194 210

AIR COMMAND AND STAFF COLLEGE

STUDENT REPORT

COMPUTER-AIDED DECISION MAKING

MAJOR MARTIN D. DUTILLY, USAF 88-0810
MAJOR KEMIT S. GRAFTON, USAF
MAJOR CLARENCE A. McFARLAND, USAF

"insights into tomorrow"

88 5 31 161

DISCLAIMER

The views and conclusions expressed in this document are those of the author. They are not intended and should not be thought to represent official ideas, attitudes, or policies of any agency of the United States Government. The author has not had special access to official information or ideas and has employed only open-source material available to any writer on this subject.

This document is the property of the United States Government. It is available for distribution to the general public. A loan copy of the document may be obtained from the Air University Interlibrary Loan Service (AUL/LDEX, Maxwell AFB, Alabama, 36112-5564) or the Defense Technical Information Center. Request must include the author's name and complete title of the study.

This document may be reproduced for use in other research reports or educational pursuits contingent upon the following stipulations:

- Reproduction rights do not extend to any copyrighted material that may be contained in the research report.

- All reproduced copies must contain the following credit line: "Reprinted by permission of the Air Command and Staff College."

- All reproduced copies must contain the name(s) of the report's author(s).

- If format modification is necessary to better serve the user's needs, adjustments may be made to this report--this authorization does not extend to copyrighted information or material. The following statement must accompany the modified document: "Adapted from Air Command and Staff College Research Report ______(number)______ entitled ______(title)______ by ______(author)."

- This notice must be included with any reproduced or adapted portions of this document.

REPORT NUMBER 88-0810

TITLE COMPUTER-AIDED DECISION MAKING

AUTHOR(S) MAJOR MARTIN D. DUTILLY, USAF
MAJOR KEMIT S. GRAFTON, USAF
MAJOR CLARENCE A. McFARLAND, USAF

FACULTY ADVISOR LT COL JAMES R. MACEY, ACSC/EDT

SPONSOR LT COL JAMES R. MACEY, ACSC/EDT

Submitted to the faculty in partial fulfillment of requirements for graduation.

AIR COMMAND AND STAFF COLLEGE
AIR UNIVERSITY
MAXWELL AFB, AL 36112-5542

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT STATEMENT "A" Approved for public release; Distribution is unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) 88-0810	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION ACSC/EDC · 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code)	7b. ADDRESS (City, State, and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION · 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. · PROJECT NO. · TASK NO. · WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)

Computer-Aided Decision Making

12. PERSONAL AUTHOR(S)

Dutilly, Martin D., Major, USAF; Grafton, Kemit S., Major, USAF

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
	FROM ______ TO ______	1988 April	133

16. SUPPLEMENTARY NOTATION

Item 12: McFarland, Clarence A., Major, USAF

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The purpose of this paper is to enhance the decision making skills and the computer literacy of middle-level military leaders by providing an elective course for Air Command and Staff College (ACSC) students. Dramatic growth in the numbers of military computers, particularly microcomputers, has led to tremendous capabilities being present at the fingertips of nearly every military member. A perception has arisen that the uses of microcomputers have not kept pace with their proliferation. Hence the elective course proposed in this paper serves as a step toward greater computer awareness and literacy among middle-level officers. Arming such officers with this knowledge should impact operational units in the future since many of these officers will be the military commanders and policymakers for years to come. The course will blend decision making techniques with the use of integrated software which the Air Force and ACSC already possess. The emphasis will be of the role the microcomputer can play in assisting a decision maker. The computer is not intended to replace common sense, intuition, or experience, but is to enhance these elements of decision making.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL ACSC/EDC Maxwell AFB AL 36112-5542	22b. TELEPHONE (Include Area Code) (205) 293-2867 · 22c. OFFICE SYMBOL

DD Form 1473, JUN 86 · Previous editions are obsolete. · SECURITY CLASSIFICATION OF THIS PAGE

The purpose of this paper is to enhance the computer literacy of middle-level military leaders by providing an elective for Air Command and Staff College (ACSC) students. Dramatic growth in the numbers of military computers, particularly microcomputers, has led to tremendous capabilities being present at the fingertips of nearly every military member. A perception has arisen, as the paper shows, that the uses of microcomputers have not kept pace with their proliferation. Hence, the elective course proposed in this paper, Computer-Aided Decision Making, serves as a step toward greater computer awareness and literacy among middle-level officers. Arming such officers with this knowledge should impact operational units in the future since many of these officers will be the commanders and policymakers of the military for years to come.

The course will teach the blending of decision making techniques with the use of integrated software which the Air Force and ACSC already possess. The emphasis will be on the role microcomputers can play in assisting a decision maker. The computer is not intended to replace common sense, intuition, or experience, but to enhance these elements of decision making.

This material will be incorporated into the ACSC Electives Program AY 89, if accepted.

ABOUT THE AUTHOR

Major Dutilly enlisted in the Army in 1966. Following stateside training, he served as an intelligence specialist assigned to the 1st Brigade, 101st Airborne Division, Republic of Vietnam. In 1968, he transferred to another intelligence specialist slot at the United States Army Field Station, Taipei, Taiwan. In late 1968, he was reassigned to Company C, 5th Special Forces Group, Republic of Vietnam. He left the Army in 1970 and earned a Bachelor of Arts degree in Journalism from the University of Texas at El Paso in 1975. After commissioning through Officer Training School in 1975, he attended Undergraduate Navigator Training at Mather AFB, California, and the KC-135 Combat Crew Training School, Castle AFB, California, completing his training in 1976. Major Dutilly's first operational assignment was with the 908th Air Refueling Squadron, Kincheloe AFB, Michigan, as a KC-135 navigator. When Kincheloe AFB closed in 1977, he joined the 924th Air Refueling Squadron, Castle AFB, California, as a KC-135 navigator, instructor navigator, and standardization/evaluation navigator until 1982. He then instructed at the KC-135 Combat Crew Training School, Castle AFB, California, for 18 months. In 1983, he moved to Mather AFB, California, as an instructor at Undergraduate Navigator Training assigned to the 452d Flying Training Squadron. After one year, he joined the Instructor Training Branch, 323d Flying Training Wing, as a Program Manager and later as Branch Chief. During this tour, Major Dutilly was an integral part of the Undergraduate Navigator Training transition to Specialized Undergraduate Navigator Training in 1986-87. Also during this assignment, he completed a Master of Business Administration at National University, Sacramento, California. Major Dutilly is married to the former Regina M. Check of Auburn, New York, and they have two sons, Michael and Joseph. His awards include the Bronze Star with one oak leaf cluster, the Meritorious Service Medal, the Air Force Commendation Medal with one oak leaf cluster, the Army Commendation Medal, the Army Outstanding Unit Award, and the Parachutist's Badge. A previously published author, Major Dutilly's article, "How to Save a Rendezvous," appeared in The Navigator magazine in 1983.

ABOUT THE AUTHOR

Major Grafton began his career in 1975 with an ROTC commission from the University of Evansville where he also earned a Bachelor of Science in Law Enforcement. After completing the Basic Security Police Officers' Course in 1975, he served until 1977 with the 91st Missile Security Squadron, Minot AFB, North Dakota as a Flight Security Officer. While at Minot, he received his Master of Public Administration degree from the University of Oklahoma in 1977. Following this tour, he served as a Shift Commander with the 8th Security Police Squadron, Kunsan AB, Republic of Korea. Returning from Korea in 1978, he served a career broadening tour at Lackland AFB, Texas, as a Basic Military Training Officer. His assignments at Lackland included the 3701st Basic Military Training Squadron for 18 months and as Chief, Training Resources Branch for an additional 18 months. Major Grafton returned to security police duty from 1981 to 1984 as the Operations Officer, 379th Security Police Squadron, Wurtsmith AFB, Michigan. While at Wurtsmith, the Professional Certification Board of the American Society for Industrial Security recognized him as a Certified Protection Professional (CPP). His position prior to attending Air Command and Staff College in 1987 was as Chief, System Security Division, Advanced Cruise Missile System Program Office (SPO), Wright-Patterson AFB, Ohio. He was the first security police officer assigned to a SPO at the Air Force System Command's Aeronautical Systems Division. Major Grafton is married to the former Jeanette Athey of Denver, Colorado. His awards include the Meritorious Service Medal with one oak leaf cluster, the Air Force Commendation Medal, the Outstanding Unit Award with one oak leaf cluster, and the Air Force Organizational Excellence Award. Previously published, Major Grafton's article, "The Laws that Apply to Honesty Testing," appeared in Security Management magazine in August, 1985.

ABOUT THE AUTHOR

Major McFarland received his Bachelor of Science degree in Engineering Sciences from the United States Air Force Academy in 1975. After graduation, he attended Undergraduate Pilot Training at Laughlin AFB, Texas, and received his pilot wings in 1976. His subsequent assignment was to Altus AFB, Oklahoma, where he received training in the C-141. Next, he was transferred to the 18th Military Airlift Squadron flying C-141 aircraft for two years. In 1979, he moved to the 35th Flying Training Squadron, Reese AFB, Texas, and served as a T-37 instructor pilot In 1981, he was selected for duty in the 559th Pilot Instructor Training Squadron, Randolph AFB, Texas He was soon chosen as a T-37 flight examiner on the Standardization and Evaluation team for the Director of Operations, Headquarters, Air Training Command. He served in this position until 1984 when he went to Headquarters, USAF There he worked as the Chief of Special Pilot Training Programs in the Training Division of the Directorate of Personnel He remained on the Air Staff for three years serving as the Program Monitor for the T-46 trainer program and Program Element Monitor for the T-37 and Flight Screening programs. Major McFarland is married to the former Etta M. Covey of Denver, Colorado, and they have two sons, Kevin and Brian. His decorations include the Meritorious Service Medal with one oak leaf cluster, the Air Force Commendation Medal, Outstanding Unit Award, and the Air Force Organizational Excellence Award

TABLE OF CONTENTS

Chapter One

INSTRUCTIONAL SYSTEMS DEVELOPMENT

INTRODUCTION

That the world we live in has tightly embraced computer technology is as obvious as the air we breathe. Everywhere one looks, the omnipresence of the computer can be seen. The range of the computer's influence runs from LCD watches to the control of traffic signals to the electronic tentacles of the largest multinational corporation.

Perhaps even more dramatic has been the spectacular growth in the use of microcomputers in recent computer history. Through 1985, more than 18 million desktop computers were sold by the top ten manufacturers. (4:119) In 1986, the top ten computer firms sold an additional three million. (5:200) Similarly, the Air Force, long a leader in adopting technology, has hardly lagged in the explosion of microcomputer use. For example, the Zenith Electronics Corporation sold the Air Force more than $400 million worth of stand-alone microcomputers between 1982 and 1986. (27:2) The Air Force Small Computer Center at Gunter AFS, Alabama, predicts that 150,000 more microcomputers, with integrated software, will be added to the Air Force inventory over the five-year span, 1987-1991. (22:1) The same office recently announced that the Air Force is planning to award a contract for the "Desktop III" computer, a follow-on system for the current Zenith Z-248 microcomputer. (1:1)

In light of the proliferation of microcomputers throughout the Air Force, the Air Command and Staff College Education Technology Division (ACSC/EDT) perceives a problem. ACSC/EDT believes that mid-level and senior military leaders are not exploiting the capabilities of powerful microcomputers which are literally at their own and their subordinates' fingertips. The main causes are that training, software, and ideas for use have lagged behind the recent massive influx of desktop computers to nearly every office and workplace. Eventually Air Force personnel will be utilizing their microcomputers more efficiently and for more and more purposes. In the meantime, ACSC/EDT perceives a need to help ACSC students, all mid-level leaders, improve their computer literacy and efficiency by using the computer as an aid in decision making, i.e., not to make the decision, but to assist the user in making a decision. The plan is to take the student beyond the level of the simpler uses they may be accustomed to and introduce them to computer-aided decision making via an ACSC elective.

as indicated above, that it is very difficult to sift through the information, analyze it, and arrive at a best solution. Hence, the assistance of a computer, and the knowledge to use one, is quite helpful.

Second, a study of ACSC students found that most of them are comfortable with the word processing capabilities of a computer but do not take advantage of the more powerful capabilities of modern desktop computers. A survey of 394 ACSC students conducted by Major Thomas James, ACSC Class AY87, discovered several things. First, 76 percent of the students owned personal computers, and 97 percent of them used the machines primarily for word processing. The use of graphics and spreadsheets followed at 38 and 33 percent, respectively. Second, over 90 percent of the students reported that they managed or supervised personnel who used microcomputers. Third, 85 percent of the officers actually used desktop computers on the job as follows: 89 percent of these officers performed word processing, 48 percent of them did database management; 31 percent utilized graphics applications; 30 percent used spreadsheets; and 24 percent employed an office-specific application. (27:14) James' findings are reflected in the business world where ". . . word processing is the Number 1 application of personal computers among Fortune 1000 firms with 91 percent of microcomputers being put to such use." (2:73) Secondary uses are spreadsheets and data bases. (2:74)

What this means is that most ACSC students have only begun to scratch the surface of the latent power of the computer because the computer can obviously be used to do many other things besides word processing. For example, another of the remarkable features of a stand-alone computer is the potential for "what if" questions. Newman Walker, a successful school superintendent for 28 years, spoke of a computer's power when he said, "It is also useful to anticipate or predict changes in the data. Pondering 'what if' situations enabled me to answer unanticipated questions. . . ." (8:470) Further, one can infer that the following quote from Personal Computing magazine would make sense to some of the above ACSC students: "Although no one's decision will be based on a chart alone, a graph can certainly aid you in explaining complex relationships and provide an effective base from which to argue. And today's personal computer programs provide a fast, inexpensive way to create those charts." (6:97) Concluding, what this points to is that while many ACSC students are computer literate, their comfort zone lies in the word processing genre rather than in the more powerful capabilities modern desktop computers offer.

A third reason for this course is the current ACSC philosophy. Three of the school stated aims are: "to provide an environment for personal and professional growth, to enhance knowledge and understanding of the Air Force's mission and capabilities, [and] to enhance professional skills required to command, manage and lead aerospace forces." (17:1) The teaching of computer skills meets all three goals. Clearly, improving an officer's decision making skills enhances personal and professional growth. This obviously carries over into enhancement of command abilities. Since computers are so widespread in the Air Force, and as James has shown, so many ACSC officers have managed personnel who use computers, any improvement in computer knowledge and understanding serves the Air Force well.

Finally, ACSC already conducts two computer elective courses. The course being discussed here is a natural follow-on since it can build on the students' knowledge foundation by taking further steps into the computer experience. (18:21A-B)

Fourth, other defense agencies conduct courses in DSS. Obviously they have seen a need for this education and training for military officers and defense officials. National Defense University (NDU) offers four elective courses addressing computer-assisted decision making (23:105-107) Also, the Defense Systems Management College (DSMC) has developed "... management modules which can be used as decision aids in the classroom at the College and can be deployed in program management offices throughout the services." (16:17) Supporting these needs is a survey conducted at NDU for 218 students at the National War College, Industrial College of the Armed Forces, and International Fellows attending NDU. It revealed that more than 74 percent of these senior officers and defense officials feel that computer knowledge is important to managers. They (54 percent) further indicate that computer training should be included in the core curriculum of NDU courses. (24:3) DSMC portrays the problem thusly:

> Although management information systems can provide the program manager with some of the information needed in the decision-making process, such systems predominately supply only historical data and current project status, usually with abundance--and many times an overabundance--of unprocessed information. A need exists, therefore, to enhance the program manager's decision-making process by examining future courses of action, assisting the "What if...?" and "Should I...?" questions, and distilling the available data into meaningful alternatives. (25:1-2)

In a related statement, Major General Clifton D. Wright, Jr., former Director of Engineering and Services, HQ USAF/LEE, opined, "It is likely that significant organizational changes will result from the use of DSS as well as from building them. Individual managers and decision makers who are able to use DSS effectively are likely to show better job performance than those who cannot use DSS." (28:54) Certainly these are graphic statements of the need for DSS.

Fifth, is there a need for improved decision making? Logically, it follows that each officer could probably benefit from improving his problem definition, information gathering and handling, analysis, and speed of processing skills. As the environment in which we operates gets more complicated, any improvement in quality and speed of decisions is useful and vital. Now, let's see where this leaves us.

After examining the current Air Force computer environment, the data deluge phenomenon, the ACSC student body and other DOD students, we also looked at the current ACSC educational philosophy and other DOD agencies who conduct similar training. There is no doubt that ACSC students can glean significant benefits from an elective course in computer-aided decision making, or DSS, for use in their future assignments in mid- and high-level leadership positions. Therefore, the ACSC/EDT perceived need for a DSS elective is justified.

ISD CONCEPT

Following is the Instructional Systems Development (ISD) discussion and validation of the elective. Each of the five steps, as outlined in AFM 50-2, Instructional Systems Development, and AFP 50-58, Handbook for Designers of Instructional Systems, will be explained and supported. The five ISD steps are:

1 Analyze system requirements.
2 Define education and training requirements.
3 Develop objectives and tests.
4 Plan, develop, and validate instruction.
5 Conduct and evaluate instruction. (19:5-7) (21:Table 1-1)

ANALYZE SYSTEM REQUIREMENTS (STEP 1)

The ISD process begins with analyzing the requirements of the educational or training system (19:10) In other words, do we need the system, and if so, what do the students need to know to meet the objectives? This first step and Step 2, Define Education and Training Requirements, comprise the Needs Assessment.

Clearly a requirement for the course has been justified. Now let us determine what the students need to know about a DSS in order to use it. First some definitions Samuel Bodily offers two forms

> [1] Think of the complete DSS as a high-level language that allows for natural English-like expression of the [decision making] model; that is, able to access corporate and vendor data bases; that has easy-to-use graphics for displaying the results, and that contains powerful computational features such as "what if," sensitivity analysis, goal seeking, extrapolation, risk analysis, and optimization [2] In its crudest form, the DSS may consist of a spreadsheet planning system such as VisiCalc (or one of its many cousins) (10:4)

Therefore, what can be taught in an ACSC elective must lie between these two extremes but closer to the latter since only 16 hours of training spread over eight weeks is available Because of the time limit, we have chosen the following definition "A microcomputer based decision support system can be designed using a number of software packages which could allow decision makers to incorporate both qualitative and quantitative elements in their analyses." (26:1) The course will teach ACSC students, via an integrated software package and decision model, how to analyze and interpret data to make a more objective and intelligent decision.

Using these definitions and concepts, it can be seen that, in order to learn to use a DSS, the essential skills required are the use of an integrated microcomputer software package, a decision model, and the ability to connect them together. Now to be more specific.

<u>What they need to know</u>:

1. Basic computer keyboard skills.
2. Use word processor.
3. Use spreadsheet.
4. Use data graphing.
5. Use data base.
6. Use integrated software package (SMART).
7. Basic math/algebra skills.
8. Basic logic skills.
9. Problem solving skills.
10. General knowledge of decision making theory, decision models, and DSS concepts.
11. Working knowledge of the decision model selected for the course.
12. Ability to use selected decision model integrated with SMART software to solve hypothetical problems and produce a printed integrated report.

The description of an integrated software package such as SMART quickly demonstrates the need for skills 1-6 above. The SMART system is primarily an integrated spreadsheet with graphing, word processing, and data base capabilities. (15:Preface-1) Also, recall that an integrated package is a major component of Bodily's simpler form of a DSS. Skills 7-9 fall into the category of the ability of a student to think through and solve a problem conceptually and reflect the "... knowledge, skill, ability, intuition, judgement, and experiential bases of the decision makers involved." (26:1) Skills 10 and 11 fit the DSS definition above and provide the essential bridge between the data and the solution, i.e., the decision model. Finally, Skill 12 is the ultimate goal of the course, being able to solve a problem and communicate its outcome through the use of an integrated software package and knowledge of decision models and theories. After delineating the skills the students need to have at the end of the learning experience, we can now move on to the second part of the Needs Assessment.

However, before continuing with the ISD process, a short discussion on the software selection for this course follows. The SMART system is an integrated software product containing today's most-needed business applications. This package fulfills our need for an integrated and cost effective system. Specifically, SMART offers an attractive bundle of modules that are easy to learn. Also, sufficient copies are currently in the ACSC inventory, and SMART is already taught in another ACSC elective. (18 21B)

The SMART system consists of three primary application modules (spreadsheet, word processor, and data base manager), two additional modules (communications and time management), and the functions necessary to combine these parts into an integrated whole. In addition, SMART provides user-friendly menus that are common throughout the system. Once the common features have been learned in one module, they can be used in all other modules. Furthermore, this system provides the ability for operators to learn and do a variety of functions easily, so they can quickly increase their productivity. (14:1-16) (15:Preface 1-2)

Besides being easy to learn, the existence of sufficient copies of SMART in the ACSC software library makes the purchase of another system unnecessary. With the average cost at $400 per copy for a new program, a significant savings is realized by using the existing SMART packages.

Finally, the existing ACSC elective, "Introduction to SMART," provides excellent preliminary training for this course. If students attend the first elective, they will have no trouble transitioning to this course. However, since the SMART modules are easy to master, as discussed above, the "Introduction to SMART" elective is not a hard and fast prerequisite.

Hence, the SMART system is a sophisticated integrated software program that is easy to learn and use, already in the ACSC inventory, and previous instruction already exists in the elective curriculum. Therefore, SMART is the chosen system to support the Computer-Aided Decision Making elective. We now continue with the ISD process.

DEFINE EDUCATION AND TRAINING REQUIREMENTS (STEP 2)

This second step of the ISD process consists of the following parts:

1. What do the students already know?
2. What do they need to be taught? This is the difference between the learning needs of Step 1 and what they already know.
3. What can and should be taught given the existing constraints? (time, equipment, costs, resources, etc.). (19:Ch 3)

Since the 16-hour time limit is a major constraint, it becomes a driving force in course development. It quickly becomes obvious that DSS experts cannot emerge from this course. This limitation also restricts what the entry level knowledge of the students must be (i.e. what they know) in order for any meaningful DSS learning to take place. Since the James survey indicates a high level of computer literacy exists in the ACSC population and two computer electives are offered currently, there are probably enough students who will meet prerequisite computer skills. Students who have completed the "Introduction to SMART" elective are, of course, eligible. Those who are comfortable with another integrated software package are eligible if the instructor determines, via interview, that the students' knowledge is adequate to transition easily to SMART.

What do the students already know?

By limiting the enrollment to students conversant in an integrated software package, the students will already have the first six requirements of basic computer keyboard skills and competence in the use of word processing, spreadsheet, data graphing, data base, and SMART or another integrated software package. However, some review of SMART will be necessary for those who took the SMART elective several weeks before and for those who have used another software package. But what else do the students already know?

Certainly ACSC students, all of whom have college degrees and more than 75 percent of them have graduate degrees, are well educated. (29:--) It also is reasonable to assume that this level of education has given them at least basic skills in math/algebra, logic, and problem solving. Additionally, their 11 to 14 years of commissioned service have honed these skills.

The next two skills, 10 and 11, are quite complicated and are not expected to be in the comfort zone of most students. In any case, general knowledge of decision making theory, decision models, DSS concepts, and a working knowledge of the decision model used in the course must be taught to establish common definitions, concepts, and solution sequences. Current decision making textbooks spend considerable time on decision theory and models and their relation to decision support systems. (10:--) (13:--)

Lastly, the twelfth skill, the ability to solve hypothetical problems by using a decision model, integrated with SMART, and to produce printed integrated reports involves active student participation in the learning experience. Successful application of this skill is the overall purpose of this course. So it must be taught.

What they need to be taught:

Summarizing the above analysis, the asterisked items need to be taught:

1. Basic computer keyboard skills.
2. Use word processor.
3. Use spreadsheet.
4. Use data graphing.
5. Use data base.
*6. Use integrated software package (SMART).
7. Basic math/algebra skills.
8. Basic logic skills.
9. Problem solving skills.
*10. General knowledge of decision making theory, decision models, and DSS concepts.
*11. Working knowledge of the decision model selected for the course.
*12. Ability to use selected decision model integrated with SMART software to solve hypothetical problems and produce a printed integrated report.

Before training requirements are fully established, they are normally prioritized to determine what really can be taught within the existing constraints Since these four skills can be taught within the constraints, prioritization is not a problem in this case. Integrated use of the SMART package is obviously critical to the conduct of this course and this drives the need for these skills as explained above. The point on general knowledge of decision making theory, decision models, and DSS concepts is less critical and could be limited in scope. The remaining points are critical and should consume the bulk of the educational experience. Successful completion of the final point, in effect, serves as a measure of each student's success in achieving the course objectives.

We now have established what needs to be taught based on the difference between what the students need to know and what they already know. Additionally, the establishment of criticality puts the proper focus on what can be taught within the given constraints.

This concludes the Needs Assessment (ISD Steps 1 and 2) With the need for the course justified, and the systems requirements and education and training requirements delineated, we can proceed to the third step of the ISD process, Develop Objectives and Tests.

DEVELOP OBJECTIVES AND TESTS (STEP 3)

Now that the Needs Assessment is complete and definite educational goals have been determined, we can proceed to the iteration of specific level of learning objectives and tests. The objectives, samples of behavior, and criterion objectives fully explain what is expected of the student. The method of testing will be covered below

Objectives

Each of the four items which need to be taught are developed below This also will be the sequence of instruction. AFM 50-62 provides the general guidance.

1 Demonstrate general knowledge of decision making theory, decision models, and DSS concepts.

Level of Learning Objective:	Know decision making theory, decision models, and DSS concepts
Sample of Behavior	Identify decision theories by characteristics
Criterion Objective	With instructor provided list, match decision theories with their characteristics with minimum instructor assistance
Sample of Behavior	Identify key elements of decision models

Criterion Objective:	With instructor provided list, match decision models with their key elements with minimum instructor assistance.
Sample of Behavior:	Identify key concepts of DSS.
Criterion Objective:	With instructor provided list, match DSS with their key concepts with minimum instructor assistance.

2. Demonstrate a working knowledge of the weighted criteria decision model used in course

Level of Learning Objective:	Apply the weighted criteria decision model to solve a given problem.
Sample of Behavior:	Solve a new problem scenario using the weighted criteria decision model.
Criterion Objective:	With given data and minimum instructor assistance, solve a previously unencountered problem using the weighted criteria decision model.

3. Use integrated software package (SMART).

Level of Learning Objective:	Apply the principles and concepts of SMART to a given scenario.
Sample of Behavior:	Enter text, create spreadsheets, create graphs from spreadsheet and develop an integrated document.
Criterion Objective:	Given instructor provided data and minimum instructor assistance, create an integrated document after entering text via the word processor, creating a spreadsheet, and creating graphs from spreadsheet.

4. Use of weighted criteria decision model integrated with SMART to solve problems.

Level of Learning Objective:	Solve previously unencountered problems using the weighted criteria decision model and the SMART package as a Decision Support System.

Sample of Behavior:	Recognize problem elements and apply solution sequence using weighted criteria decision model and SMART. Enter text, create spreadsheet, create graphs from spreadsheet, and create sections of integrated document. Assemble and print an integrated document from previously created sections.
Criterion Objective:	Given a new problem, produce a printed integrated report of the solution using the weighted criteria decision model and the SMART package as a Decision Support System with minimum instructor assistance.

Tests.

The test for completion will be the last objective. If the students can produce a printed integrated report of a correct solution to a previously unencountered situation, they certainly have satisfied the intent of this course and achieved its objective.

PLAN, DEVELOP, AND VALIDATE INSTRUCTION (STEP 4)

As one can see from Step 3, we have decided where the students should be at the end of this course. Now, what might be the best way to achieve the desired results, that is, the fourth level of learning objective: Solve previously unencountered problems using the weighted criteria decision model and the SMART package as a Decision Support System?

Planning and Developing:

Concerns now center around instruction determinants such as lesson sequence, type of instruction, media selection, desired levels of learning, lesson organization, and constraints.

First, the sequence of instruction is, of course, an important aspect of learning because it provides smooth training without gaps or duplication. It also foments continued student interest and the desired learning in each lesson, especially when these skills are needed later in the course and afterward. (19:34) To illustrate, the students should be taught to walk, then to jog, and finally, to run. Each step builds on its predecessor. Since the students already know how to crawl, figuratively speaking, no instruction will be devoted to that activity. Hence we have an appropriate and smooth sequence with little or no duplication.

Secondly, the type of instruction was selected using the guidance in AFM 50-62, Handbook for Air Force Instructors, and is tied to the desired level of learning For example, Objective One: Know decision making theory, decision models, and DSS concepts; is at the knowledge level so a lecture is appropriate. This insures that a large amount of information can be presented during a short training session. This is further reinforced by assigned reading/handouts. (20:Table 18-1)

Third, media needs to be appropriately matched to the type of instruction. Again using Objective One as an illustration, overhead slides and handouts are suitable and recommended medium for this lesson's lecture format. (19:Table 5-3)

Fourth, correctly chosen lesson organization patterns facilitate instruction by making it easier for students to learn. "The lesson material will often organize itself with one pattern and strategy than with another." (20:6-3) Common relationships used in lesson plans are time, space, cause-effect, problem-solution, pro-con, topical, and combined patterns. (20:Ch 6). For example, the first objective, in its discussion of decision theory, will be largely topical, supported by sufficient definitions and examples.

Fifth, two major constraints, time and computer availability, affect the learning outcomes of this course. Since the ACSC elective format allots a mere 16 hours to the course, only so much material can be covered or absorbed. Therefore, the developed lesson plans must reflect this important factor. Further, the ACSC computer environment restricts the class size due to the availability of only six computers in the ACSC laboratory. If we limit the class to one student per machine, learning will be optimized since each student will have his own keyboard. On the other hand, if a higher student-to-computer ratio is allowed, less learning might occur for each student, but more of them can be accommodated and this will provide a larger base from which to validate the course. We recommend accepting up to two students per computer, or up to 12 per course. If the Air War College computer laboratory is used in the future, additional students can be taught. Relatedly, while computers are present in each seminar room, they are not currently linked together, and student separation would make instructor control impossible. However, computer time logged out of class could be done in the seminar rooms (i.e. working on student projects or practice with the SMART software).

Following is the general sequence of instruction which conforms to the order of the developed objectives. Also included are the types of instruction and media selections to achieve the objectives.

1. Demonstrate general knowledge of decision making theory, decision models, and DSS concepts.

Level of Learning Objective:	Know decision making theory, decision models, and DSS concepts.
Type of instruction:	Lecture, student-instructor interaction.

Media selection:	Overhead slides, handouts, reading.

2. Demonstrate a working knowledge of the weighted criteria decision model used in course.

Level of Learning Objective:	Apply the weighted criteria decision model to solve a given problem.
Type of instruction:	Lecture, student-instructor interaction, demo-performance, student practice with problem
Media selection:	Overhead slides, handouts, reading.

3. Use integrated software package (SMART).

Level of Learning Objective:	Apply the principles and concepts of SMART to a given scenario.
Type of instruction:	Lecture, student-instructor interaction, demo-performance, student practice with computer.
Media selection:	Overhead slides with computer screen interface, computers, handouts, reading.

4 Use of weighted criteria decision model integrated with SMART to solve problems.

Level of Learning Objective:	Solve previously unencountered problems using the weighted criteria decision model and the SMART package as a Decision Support System.
Type of instruction:	Lecture (review), student-instructor interaction, self-paced student performance, i.e., produce report.
Media selection	Overhead slides (review), computers.

Validating

Having planned and developed the lessons, it is now time to try out the course and examine its effectiveness in the learning environment.

While the preferred method of validation would be with control groups using pre- and post-instruction test procedures, we suggest the following methods:

1. Teach the elective during Mix Three of ACSC Class AY 88 (Spring 1988)
2. Conduct the elective using new ACSC Faculty Instructors as students during June-July 1988.

First, teaching the class to the current ACSC class provides validation as soon as possible. Also, required adjustments can easily be accomplished between May 1988, when the elective ends, and October 1988, when it would be needed for ACSC Class AY89. Further, the ACSC elective format allows students a wide selection of classes. Presumably, they will choose a course in which they have considerable interest and are probably willing to put up with the minor irritants associated with the first time a course is taught. Additionally, this validation group of students are real ACSC students, the intended targets of this course.

Second, conduct the class using new ACSC Faculty Instructors as students during June-July 1988. These "students" would closely approximate ACSC students since they would have just completed ACSC themselves. It is important to conduct the course in the same manner it will be done in the normal elective venue, that is, teach 16 hours in two-hour segments for eight weeks. This validation group would provide another opportunity to adjust the instruction prior to the next academic year.

If validation results are satisfactory, adjustments should be made and included as an elective course for ACSC Class AY89. This will be further discussed in Step 5 of the ISD process, Conduct and Evaluate Instruction.

CONDUCT AND EVALUATE INSTRUCTION (STEP 5)

As mentioned, the first choice for validation will take place during Mix Three, ACSC Class AY88, by conducting the course. Simultaneously, the course will be evaluated. Based on instructor and student inputs, end-of-course critiques, and Class AY88 critiques, conclusions can be drawn to show where the course should be improved or changed. ACSC/EDT has offered this criterion as a proper conclusion for the instruction: A "Good" rating on the end-of-elective critique from 75 percent of the elective participants. We suggest, however, that the best benchmark for determining the adequacy of instruction will be the student final reports generated as proof of meeting the fourth level of learning objective. Solve previously unencountered problems using the weighted criteria decision model and the SMART package as a Decision Support System. The relative quality and completeness of these reports will show how close to desired learning targets the trajectory of instruction has landed. Finally, since the ISD model depicts feedback between all steps, this allows an opportunity to make course changes before the course is taught a second time. (20:Table 1-1)

If the elective is adopted, before any instruction starts, the next class should be given an end-of-course problem on the first day of class, or prior to class. While the students would not be expected to solve the problem completely, any segment of the problem which can be solved without benefit of instruction would indicate that some of the course might be superfluous and might be in need of revising. It would further show what the students' entering knowledge level is, thereby confirming or modifying the original *ISD Needs Assessment*. *Similarly*, a post-test would serve to prove that learning did, in fact, take place. The student project called for at the course's end is a suitable post-test. Additionally, inadequate solution of the project would point to deficiencies in the instruction and would call for revisions in the course.

ISD SUMMARY

The ISD process is now complete except for the feedback which will continue. We have shown that a course in computer-aided decision making incorporating a decision support system (DSS) is justified for inclusion in the ACSC electives curriculum. Also, the entire five step ISD model was exercised. A complete Needs Assessment determined the starting point for the instruction by finding what needs to be taught. Next, objectives and a suitable test of learning were evolved. Then, the lesson planning and development and a suitable validation were included. Finally, the phase of conducting and evaluating the course was outlined. The complete lesson plans, overhead slides and graphics, and student handouts can be found in Appendices A, B, and C, respectively.

Chapter Two

LESSONS LEARNED

During the development of this elective course, several things were noted which deserve mentioning First, ACSC students who tackle a curriculum development project would be well served to take the ISD elective in Mix One This proved to be very useful to us in learning and using the ISD process Second, don't overlook other DOD training agencies, both inside and outside Air University, as sources for similar training materials This is appplicable for a new course like ours or an update of an existing course Third, if computers are part of a project, no stone should be left unturned in finding the experts Many times they are not assigned only to offices which use or manage computers extensively We found that considerable computer expertise shows up in unexpected places and persons, so it pays to ask around The ACSC staff and student body have many computer "gurus" who aren't carrying a computer AFSC

Articles and Periodicals

1. Bass, Brad. "AF Begins Planning Replacement Micro." Government Computer News (9 October 1987), p. 1+.

2. Ditlea, Steve. "Word Processing." Personal Computing (October 1986), pp. [illegible].

3. Glagan, Patricia. "How to Avoid Datacide." Training and Development Journal (October 1986), pp. 54-56.

4. H[illegible], Patrick. "The Personal Computing 500." Personal Computing (October 1986), pp. 117-127.

5. [illegible], Russ, et al. "The Personal Computing 500." Personal Computing (October 1987), pp. 197-217.

6. [illegible], Cheryl. "Visual Decision Making." Personal Computing (January 1987), pp. [illegible].

7. [illegible], Charles. "Decision Support Software." Popular Computing (October 1985), pp. [illegible].

8. [illegible], Jeremiah B. "The Human Dimensions of Data-Based Decision Making: An Interview with Newman Walker." Phi Delta Kappan (February 1987), pp. [illegible]-475.

9. Walker, John R., Air Vice Marshal, RAF. "Modern Information Systems: Help or Hindrance?" Jane's Defence Weekly (7 March 1987), pp. [illegible]-362.

Books

1. [illegible], Samuel E. Modern Decision Making. New York: McGraw-Hill, 1955.

2. [illegible], Robert H. The Why, What, and How of Decision Support. New York: American Management Publications Division, 1984.

3. [illegible], Peter F. Decision Making. New York: McGraw-Hill, [illegible].

4. [illegible], John. Megatrends: Ten New Directions Transforming Our Lives. New York: Warner Books, 1982.

5. [illegible], Andrew [illegible]. [illegible] SMART. Indianapolis, IN: [illegible], [illegible].

15 The SMART System Manual Overland Park KS: Innovative Software, 1985.

Official Documents

16 Defense Systems Management College. Defense Systems Management College 1986 Catalog. Fort Belvoir VA. 1986.

17 Headquarters Air University. ACSC Operations Handbook - AY 1988. Air Command and Staff College, Maxwell Air Force Base AL. 1988.

18 Headquarters Air University. ACSC Electives Program Handbook - AY 1988. Air Command and Staff College, Maxwell Air Force Base AL. 1988.

19 Headquarters United States Air Force. AFM 50-2, Instructional Systems Development. Randolph Air Force Base TX: HQ ATC/TTSA. 15 July 1986.

20 Headquarters United States Air Force. AFM 50-62, Handbook for Air Force Instructors. Randolph Air Force Base TX. HQ ATC/OC. 15 January 1984.

21 Headquarters United States Air Force. AFP 50-58, Handbook for Designers of Instructional Systems. Randolph Air Force Base TX. HQ ATC/XPTI. 15 July 1978.

22 Headquarters United States Air Force. AFRP 700-2, BYTE LINE. Gunter Air Force Station AL. HQ SSC/SSMC. 1 July 1986.

23 National Defense University. National Defense University 1986-1987 Catalogue. Fort McNair, Washington DC. 1986.

24 National Defense University. NDU Course 130. Course materials used at National Defense University, Fort McNair, Washington DC. 1986.

25 Scanlon, Katherine M. and Schutt, Harold J. "The Program Manager's Support System (PMSS): An Executive Overview and Systems Description." A handbook prepared at Defense Systems Management College, DMSC/DRI, PMSS Directorate, Fort Belvoir VA. 1986.

Unpublished Sources

26 Barrie, C. A., Captain, RAN, et al. "A Decision Support System for Evaluating Micro-Computer Requirements for National Defense University." Student project prepared at the National Defense University, Fort McNair, Washington DC. November 1986.

27 James, Thomas G., Maj, USAF. "ACSC Introduction to Microcomputers for Air Force Leaders." Research study prepared at the Air Command and Staff College, Maxwell Air Force Base AL. 1987.

[illegible]. [illegible], Douglas E., 1Lt, USAF, and Van Delsen, Danny E., Capt, USAF. "A Decision Support System for Bare Base Planners." Master's thesis, Air Force Institute of Technology, Wright-Patterson Air Force Base OH, 1984.

Other Sources

[illegible]. [illegible], E. A., Maj, USAF. ACSC/ED, Air Command and Staff College, Maxwell Air Force Base AL. Interview, 3 December 1987.

APPENDIX

APPENDIX A

LESSON
PLANS

LESSON PLAN # 1 (2 HOURS)

INTRODUCTION

ATTENTION

Introduce yourself, let class introduce themselves, discuss computer experience. (10 minutes)

MOTIVATION

As desired.

COURSE OVERVIEW (5 minutes) Slide 1-1

COURSE OBJECTIVE

To improve decision making through a better comprehension of decision theory and decision models using a microcomputer.

Eight lessons (16 hours) Slide 1-2

Lesson 1
- Introduction
- Decision Theory

Lesson 2
- Review
- Decision Modeling
- Decision Support Systems
- Weighted Criteria Decision Model

Lesson 3
- Review
- Introduction to SMART

Lesson 4
- Spreadsheet
- Graphing

Lesson 5
- Review
- Problem A

Lesson 6
- Problem A
- Introduce Problem B

Lesson 7
- Problem B

Lesson 8
Problem B Report
Review
Summary

OBJECTIVE: Demonstrate a general knowledge of decision making theory — Slide 1-3

DEVELOPMENT

I. Decision Theory — Handout 1-1*

A. Introduction

1. How are decisions made? (3:1)**
   a. guessing
   b. take poll
   c. voting
   d. following a hunch
   e. experience
   f. systematic approach

2. Decision Loop (3:1) — Slide 1-4
   a. become aware of problem
   b. define problem
   c. analyze alternatives & consequences
   d. select solution
   e. implement solution
   f. provide feedback

3. Importance of decision (3:1-3) — Slide 1-5
   a. determines method
   b. size/length of commitment
      1) considerable capital/effort = major decision
      2) long-term impact = major decision
   c. flexibility of plans - action that cannot be easily reversed may be of major significance
   d. certainty of goals & plans
      1) following long-standing policies on how to handle certain situations makes decision easy
      2) no policies/history (precedent), decision may assume major importance

e. quantifiability of variables
    1) well defined, accurate quantifiable data = minor importance
    2) if building a complex item or if program costs are based on broad estimates = greater importance
f. human impact - human impact great (many people) = decision important

4. Time-cost relationship (3:3-6) Slide 1-6
    a. Cost-benefit time curve
        1) benefit from more info increases, then levels off
        2) costs of waiting continues to increase
        3) curve varies for each situation
    b. Cost-uncertainty time curve Slide 1-7
        1) want to reduce uncertainty
        2) do not exceed crossover point
        3) uncertainty never reaches zero
        4) decisions with major ramifications requires collecting adequate data to select the best course of action
    c. Optimum decision point curve - delaying decision beyond optimum point results in increasing total cost (opportunity) costs, $, etc. Slide 1-8

Interim Summary: We have started an introduction to decision theory. After the break, we will continue this topic.

15 Minute Break

5. Decision ingredients - decision making is based on the following basic ingredients (3:7-8) Slide 1-9
    a. facts
        1) pro & con to determine boundaries
        2) if facts cannot be obtained, decision must be based on whatever data is available
    b. knowledge
        1) if decision maker has knowledge, then it can be used to select a favorable course
        2) if not, seek advice from experts

c. experience - use experiences in solving previous similar problems to help solve problem at hand
d. analysis
   1) mathematical analysis may supplement decision making
   2) if model does not exist, intuition may be necessary
e. judgement
   1) ties it all together
   2) needed to combine the above ingredients to select the best course

***6. Decision problems - Problem areas encountered when making decisions (3:9-11) — Slide Opt.

a. misdirection - wrong question, right answer
b. sampling
   1) sample size
   2) sample must represent facts
c. bias
   1) may be in decision maker
   2) also may be in data source (expert)
d. ubiquitous average - averages may bury important extremes
e. selectivity
   1) reject unfavorable results
   2) choosing methods that will yield only favorable results
f. interpretation
   1) inappropriate interpretation of facts
   2) lack of expertise or understanding
g. jumped-at conclusion - already favor a solution and initial data supports "gut feeling"
h. meaningless difference - applying significance to insignificant differences in data
i. connotation - inappropriate conclusions caused due to emotional content or implication
j. status - communication break down due to rank or position

B. Non-mathmatical decision making techniques - fact finding

1. Can be individual or group
    a. in either case, consider systematic approach
        1) consider time - Optimum decision point
        2) follow decision loop
        3) consider importance
        4) use available information (decision ingredients)
    b. examples of groups: (3:53-56) — Slide 1-10
        1) Brainstorming
        2) Nominal Group Technique - ACSC
        3) Synectics - Similar to Brainstorming except formalized methodologies are used to develop and select solutions
        4) Consensus thinking
            a) knowledge is spread among several experts
            b) formalized process to develop consensus
        5) Delphi technique
            a) technique using experts to predict future
            b) experts forecast in isolation, then consensus is found

C. Group decision making (3:30-34) — Slide 1-11

1. Advantages
    a. broader background
        1) biggest advantage
        2) broad base of experience and opinions
    b. spread of authority
        1) used when management does not want to delegate too much authority to an individual
        2) balance-of-power
    c. special interest group - support decision if involved in decision making process
    d. coordination of action - bringing specialists together frequently improves coordination of planning/execution

e. information exchange
   1) all parties simultaneously learn the importance of the decision and why it was made
   2) do not have to spend time explaining decision to everyone
f. span of authority - decision may require combined actions from numerous work sections
g. motivation - participative decision making
h. avoidance of action - sometimes groups can be used to avoid action

2. Disadvantages
   a. cost
      1) primary disadvantage
      2) labor hours, travel, lodging, etc.
   b. compromise decisions - compromise decisions can be less than optimal
   c. failure - members may find it impossible to agree
   d. guided decisions - if progress is not made, leader may guide process which causes:
      1) members to withdraw and leader makes decision - individual decision
      2) group splits, making compromise impossible
   e. committee responsibility - no one responsible for decision; therefore, no one responsible for carrying it out
   f. strong minority - if unanimous decision is desired, minority may force compromise to a less than optimum position
   g. management replacement - could replace "centralized control"
   h. research - committee should not be used to do research - wastes time
   i. trivial decisions - groups should not waste time discussing trivial matters or making trivial decisions
   j. authority - committee members should have the authority to make appropriate decisions

SUMMARY/REVIEW Slide 1-12

As required - Next time, we will talk about mathematical decision making, Decision Support Systems and the Weighted Criteria Decision Model. (Pass out Handouts for Lesson 2)

* Handout 1-1 should be passed out approximately one week prior to the first class.

** Footnotes refer to the supplemental bibliography at Appendix D. Material cited was generally extracted from the sources indicated. Citations are designed both to give credit to the author(s) and to provide a reference for the instructor.

*** Time permitting/optional

LESSON PLAN #2 (2 Hours)

INTRODUCTION

ATTENTION
As desired

MOTIVATION
As desired

REVIEW — Slide 2-1
As required

OVERVIEW
Discuss decision modeling, Decision Support Systems, and the Weighted Criteria Decision Model

OBJECTIVE: Demonstrate a general knowledge of decision models (30 minutes) — Slide 2-2

DEVELOPMENT

I. Decision models — Handout 2-1

A. Mathematical decision making (MDM)

1. MDM involves expressing an action or activity in quantifiable terms

2. Generally requires developing a mathematical model

3. Why model? (2:5-6) — Slide 2-3
   a. necessity
      1) data deluge
      2) model is not goal; instead, decision is goal
   b. better decisions
      1) consider more of the relevant facts
      2) consider longer periods
      3) sensitivity analysis - improves understanding of factors, particularly uncertain factors
   c. insight - better understanding of how factors relate to each other
   d. aid to presentations
   e. intuition - modeling complex problems can provide insight into the issues

4. A modeling discipline (2:6-7)
   a. reliable - reliable modeling requires disciplined development of the model
   b. accurate - must accurately reflect assumptions and reality
   c. simplicity
      1) improves reliability
      2) decreases investment
      3) should be flexible/extendible (account for changes)

5. For almost everything that occurs or will occur, a model can be developed to simulate action or predict outcome. The key is to select the model that is most appropriate for your situation.

B. MDM examples

1. Probability
   a. examples of coin & dice
   b. example: Slide 2-4
      1) P X C = V
      2) P - Probability
      3) C - Cost
      4) V - Value
      5) if P X C > V, then this is a *good* decision
      6) probability must be accurate
         - sometimes subjective
         - bias

2. Decision tree (3:118-119)
   a. uncertainty is normally part of every decision - decision trees help you visualize how uncertainty affects a particular alternative
   b. basic example Slide 2-5
   c. steps - example of return on an investment of $10,000 Slide 2-6
      1) lay out diagram
      2) assign payoff
      3) assign probabilities
      4) select best strategy
   d. again, graphic display of issue helps visualize situation

3. Weighted Criteria Decision Model
   a. falls into this (MDM) category
   b. just mention for now; we get into more detail later today

4. There are numerous other examples of types of MDM ranging from simple to complex. You must match the technique to the need.

OBJECTIVE: Demonstrate a general knowledge of Decision Support Systems (DSS) (15 minutes) Slide 2-7

I. Introduction (1:58) Handout 2-2

A. DSSs do not make decisions; instead, help you make decisions (hopefully better)

B. DSSs allow you weigh alternative more dispassionately

C. Pros Slide 2-8
1. Preprogrammed
2. Fairly simple
3. Advantages of modeling
4. Uses computer, compatible with integrative software

D. Cons
1. Time consuming
2. Can be used to legitimize bad decisions - bias

II. General types (1:60-61,122-124)

A. Computer-aided

1. Weighted criteria models

2. Examples
a. Decision Aid
b. Decision Analyst
c. Lightyear
d. Expert Choice
e. Trigger

B. Decision-modeling

1. Help make strategic, direction-setting decisions

2. Examples
a. Encore
b. MAC-PAC/PC
c. IFPS/Personal
d. The Confidence Factor

Interim Summary: Today we have discussed decision modeling and Decision Support Systems. After the break, we will talk about the Weighted Criteria Decision Model.

15 Minute Break

OBJECTIVE: Demonstrate a general knowledge of the Weighted Criteria Decision Model (45 minutes) Slide 2-9

I. General Information

A. The Weighted Criteria Decision Model (WCDM) is a type of mathematical decision making

B. It is a systematic approach to decision making and is very similar to the Decision Loop (re. lesson #1)

C. It is particularly suited for decision modeling

1. Fairly simple

2. Demonstrates an excellent example of using integrated software
   - a. word proccessing helps in writing the report
   - b. spreadsheet facilitates calculations
   - c. graphing improves presentation of information
   - d. data bases can be effectively used for loading information, if available

II. Discussion

A. WCDM works particularly well if you are purchasing an item (acquisition)

1. Example - purchasing a car
   - a. you first determine you need a car
   - b. you then develop criteria
     - 1) new versus used
     - 2) cost range
     - 3) options
     - 4) gas mileage
     - 5) etc.

c. now, you determine which cars you can buy (alternatives)
d. you weigh how each car meets your criteria
e. then, you pick the best option

2. You may not be as systematic as this, but you very likely go through a mental exercise similar to above example

B. The WCDM basically involves the above process, the steps are (brief overview): (5:22-24) — Slide 2-10, Handout 2-3

1. Problem definition

2. Statement of purpose

3. Criteria definition

4. Criteria assessment

5. Alternatives

6. Weighting

7. Scoring

8. Analysis

9. Conclusions

C. WCDM is an expanded version of the car example; however, with WCDM

1. You quantify your criteria

2. You can use a computer - integrated software

3. You can use sensitivity analysis to see what if?

4. Allows a more dispassionate decision

D. Now, an explanation of the steps (5:22-24) — Slide 2-10

1. Problem definition
   a. normally in an acquisition, this step is fairly simple

b. make sure you really understand the tasking - what are the assumptions?
c. solve the right problem
d. ensure you have considered all the guidance, as practical
e. consider the options of "doing nothing"
f. record your information
g. car example - need transportation

2. Statement of purpose
 a. after defining the problem, develop a purpose statement
 b. car example - purpose to buy a car

3. Criteria definition
 a. first determine top level criteria, which may be broken into sub-elements
 b. if you only have a few criteria, only top level may be needed
 c. consider all the criteria - use brainstorming, if appropriate
 d. car example - cost, gas mileage, reliability and maintainability, trunk space, color

4. Criteria assessment
 a. important step
 b. consider external factors
  1) decision-chain
  2) guidance
 c. set limits/boundaries - car example: $12 - $16,000
 d. determine which criteria are most important
 e. assess relative values to criteria and normalize to 100% - example — Slide 2-11
 f. develop consensus
 g. Will your criteria and their values stand up to scrutiny?

5. Alternatives — Slide 2-10
 a. research all alternatives
 b. avoid omitting alternatives that may not pass - criteria could be changed
 c. car example - Ford, Chevrolet, etc.

6. Weighting
 a. assign weights to limits - give example — Slide 2-12
 b. develop linear formula — Slide 2-13

c. calculate weights for alternatives - car example — Slide 2-14

d. note: in real life, all weighting may not be linear, we assume this for this course

e. Will your weights stand up to scrutiny? - you consider this again in analysis

7. Scoring — Slide 2-10

   a. multiply weights X criteria values - car example — Slide 2-15

   b. compare scores - car example — Slide 2-16

8. Analysis — Slide 2-10

   a. reconsider relative weights and criteria values — Slide 2-17

   b. change values (What if?) and check the effect on overall solution - sensitivity analysis

   c. this is where computer really becomes useful

9. Conclusions - develop conclusions based on analysis

SUMMARY/REVIEW — Slide 2-18

As required - Next time we will start discussing how to use integrated software, SMART, to assist the UCDM process

LESSON PLAN # 3 (2 HOURS)

INTRODUCTION

ATTENTION
As required

MOTIVATION
As required

REVIEW
As required

OVERVIEW
Discuss business software packages and integrated packages. (i.e., Enable, Smart, Framework, etc.)

OBJECTIVE: Demonstrate the ability to load and boot up with Smart, enter text, handle files and integrate the word processor with other modules.

DEVELOPMENT

I. Overview of Smart: (45 minutes)

A. Smart System Modules:

1. Word Processor:
   a. fully capable module
   b. common features
   c. windows
   d. can include graphs from the spreadsheet module

2. Spreadsheet:
   a. features you are accustomed to
   b. windows
   c. formulas in the worksheet
   d. business Graphics
      1) bar graphs
      2) line graphs
      3) high-low graphs
      4) pie charts

3. Other Modules:
   a. data base
   b. time manager
   c. communications

B. Common features

1. Confidence levels
    a. set from parameter menu
    b. help speed up work
    c. can use level you need

2. Quick keys
    a. function keys (F1-F10)
    b. control key (Ctrl)
    c. alternate key (Alt)
    d. Example
        1) F1 Help
        2) Alt S = Save a file to disk

C. Starting Smart

1. DOS review
    a. C: prompt
    b. Change Directory (CD\smart)

2. Begin Smart
    a. C: smart
    b. goto module directly
        1) smart w = word processor
        2) smart s = spreadsheet

Interim Summary: The Smart system is a business software package that contains six application modules. These modules are fully capable and have many of the same common features. Once you learn these features, they are usable throughout Smart. Also, getting started with Smart is simple. The word processor will be the first module we will discuss.

15 Minute Break

II. Using Smart's Word Processor (45 minutes)

A. Introduction to the Word Processor (4:323-394)

1. Enter text
    a. two modes
        1) command
        2) text mode

2. Handling files
    a. ESC to toggle modes
    b. backslash (/) to move in menu
    c. Alt L to load file
    d. Alt S to save file

3. Handling and moving Text
   a. cut and paste
   b. Alt M to move blocks
   c. Alt I to insert
   d. Alt D to delete
   e. Alt V and Alt H for windows
   f. formatting is done from command menu's

4. Search and replace text
   a. F3 to find and replace text
   b. F5 to find and replace string
   c. F4 is GOTO command

5. Printing text
   a. Alt P will give you print menu

B. Integrating Word Processor to other Smart Modules

(4:395-404)

1. Reading files into text
   a. Command Menu 4 - Read

2. Writing text into a file
   a. Command Menu 4 - Write

3. Sending text to other Modules
   a. Command Menu 5 - Send
   b. to change to ASCII
      1) Command Menu 4 - Change Type

Students work on word processor commands, enter text and handle files in the time remaining. Instructor provides assistance as required.

SUMMARY/REVIEW

The primary reason to use a word processor is the ability to cut and paste a document. By having the ability to integrate data, the word processor can produce a high-quality product. In the next session we will continue by discussion about the Smart spreadsheet and it's graphics command.

LESSON PLAN # 4 (2 HOURS)

INTRODUCTION

ATTENTION

As required

MOTIVATION

As required

REVIEW

Review Smart start up procedures.

OVERVIEW

Discuss how everyone has had a chance to work with paper spreadsheets and some may have had experience with electronic spreadsheets (i.e. Lotus 1-2-3 and SuperCalc 3)

OBJECTIVE: Demonstrate the ability to load the Smart spreadsheet module, enter data, handle files and integrate the spreadsheet with other modules.

OBJECTIVE: Demonstrate the ability to define a graph, generate a graph, view a graph, print a graph, edit a graph, and send a graph to the word processor.

DEVELOPMENT

I. Using Smart's Spreadsheet (45 minutes)

A. Introduction to the Spreadsheet (4:197-292)

1. Rows and Columns
   a. each cell has address
   b. example - r5c5

2. Spreadsheet size
   a. 999 rows and 9999 columns
   b. ignores blank cells to save memory

3. Entering data
   a. two modes - like word processor
   b. F4 - GOTO
   c. enter data at cursor
   d. = to enter formulas

4. Handling files
   a. Alt L - Load
   b. Alt S - Save
   c. Alt U - Unload

5. Handling and moving data
    a. Alt C - Copy
    b. Alt M - Move
    c. Alt I - Insert
    d. Alt D - Delete

6. Printing worksheet data
    a. Alt P - Print

B. Integrating the spreadsheet with other modules (4:295-299)

1. Reading external files into worksheet
    a. Command menu 4 - Read
    b. data will insert at cursor

2. Writing worksheet data to different files
    a. Command menu 4 - Write

3. Sending data to the word processor
    a. Command menu 5 - Send
    b. three options
        1) Document
        2) Graphic
        3) Both

Students work on spreadsheet commands, enter data and handle files in the time remaining. Instructor provides assistance as required.

Interim Summary: We have discussed and practiced the Smart spreadsheet module. After the break we will cover the graphics command of the spreadsheet. The data for graphics comes from the spreadsheet.

15 minute Break

C. Using Graphics command (45 minutes) (4:301-322)

1. Defining graph
    a. Ctrl G
    b. choose define command

2. Choosing graph type
    a. bottom of graph definition screen 1
    b. screen 2 is used for entering data

3. Displaying the graph
    a. choose generate command
    b. save screen command to view latter

4. Printing a graph
    a. Matrix-Print command

5. Editing a graph
    a. choose edit command

6. Sending graph to word processor
    a. be in word processor module
        1) be in desired document
    b. use graphics insert command
    c. graph will not appear on screen
        1) will appear when printed
    d. to see graph use graphics view command
    e. must be in enhanced mode to print

Students work on graphics command, enter data, define graph, generate graph, view graph, print graph, and edit graph in the time remaining. Instructor provides assistance as required.

SUMMARY/REVIEW

The Smart spreadsheet is an electronic worksheet that can help understand and manipulate data. The graphics command further enhances the spreadsheet by displaying the data in graph format. Both these modules can integrate with other modules of Smart to produce a high-quality product. In the next session we will continue by using the decision model with Smart to solve a problem.

LESSON PLAN # 5 (2 HOURS)

INTRODUCTION

ATTENTION
As required

MOTIVATION
As required

REVIEW
Review Smart modules and Weighted Criteria Decision Model.

OVERVIEW
Up to now we have discussed the Weighted Criteria Decision Model and practiced using Smart. Today we will use a scenario and apply the decision model to solve and report a solution in class.

OBJECTIVE: Apply the principles and concepts of Smart to a given scenario.

OBJECTIVE: Solve previously unencountered problems using the weighted criteria model and the Smart package as a Decision Support System

DEVELOPMENT

I. Using Decision Model with Smart (2 hours)

A. Instructor will handout Problem A (Handout 5-1) to students and review instructions on procedures.

B. Students will use time allotted to solve problem using Smart and the weighted criteria model.

C. Answer will be provided to Instructor during 1st hour of lesson 6.

D. Instructor provides assistance as required

SUMMARY/REVIEW

Today's scenario gives us an example of how to apply the principles and concepts of Smart to a problem. The next scenario will be more complex and will further your ability to use Decision Support Systems and Smart to solve problems.

LESSON PLAN #6 (2 HOURS)

INTRODUCTION

ATTENTION
As required

MOTIVATION
As required

REVIEW
Review Smart modules and Weighted Criteria Model.

OVERVIEW
Provide answer to and review Problem A. Hand out Problem B. Students start work on Problem B.

OBJECTIVE: Apply the principles of Smart to a given scenario.

OBJECTIVE: Solve previously unencountered problems using the weighted criteria model and the Smart package as a Decision Support System.

DEVELOPMENT

I. Using Decision Model with Smart. (2 hours)

A. Instructor will provide answer to Problem A and review will students.

B. Instructor will handout Problem B (Handout 6-1) to students amd review instructions on procedures.

C. Students will use time alloted to solve problem us ing Smart and the weighted criteria model.

D. Students will have the two hour block in this lesson and two hour block in lesson 7 to work on this problem.

E. Answer will be provided in lesson 8.

F. Instructor provides assistance as required.

SUMMARY/ REVIEW

Todays scenario gives us an example of a more complex problem and will futher your ability to use Decision Support Systems and Smart to solve problems. Next lesson will proved more time to work on this scenario.

LESSON PLAN #7 (2 HOURS)

INTRODUCTION

ATTENTION
As required

MOTIVATION
As required

REVIEW
Review Smart modules and Weighted Criteria Model.

OVERVIEW
Students continue work on Problem B.

OBJECTIVE: Apply the principles of Smart to a given scenario.

OBJECTIVE: Solve previously unencountered problems using the weighted criteria model and the Smart package as a Decision Support System.

DEVELOPMENT

I. Using Decision Model with Smart. (2 hours)

A. Students will use time alloted to solve problem us ing Smart and the weighted criteria model.

B. Students will have the two hour block in this lesson to continue to work on this problem.

C. Answer will be provided in lesson 8.

D. Instructor provides assistance as required.

SUMMARY/ REVIEW

Todays scenario gives us an example of a more complex problem and will futher your ability to use Decision Support Systems and Smart to solve problems. Next lesson will proved more time to put final touches on this scenario and provide the solutions.

LESSON PLAN #8 (2 HOURS)

INTRODUCTION

ATTENTION

As required

MOTIVATION

As required

REVIEW

Review Smart modules and Weighted Criteria Decision Model.

OVERVIEW

Students wrap up work on Problem B. Instructor reviews solution to Problem B. Summarizes course and passes out course critique.

OBJECTIVE: Apply the principles of Smart to a given scenario.

OBJECTIVE: Solve previously unencountered problems using the weighted criteria model and the Smart package as a Decision Support System.

DEVELOPMENT

I. Using Decision Model with Smart (45 minutes)

A. Students will wrap up work on using Smart and the weighted criteria model to solve Problem B.

B. Instructor provides assistance as required.

15 Minute Break

II. Provide solution to Problem B (45 minutes)

A. At least one student briefs the solution to Problem B. All students turn in written report of solution.

B. Instructor reviews correct solution. (Handout 8-1)

SUMMARY/ REVIEW

Todays scenario gives us an example of a more complex problem and will futher your ability to use Decision Support Systems and Smart to solve problems. This course has provided you with a general knowledge of decision making theory, decision modeling, decision support systems and the weighted criteria model. Also, it has provided you the opportunity to apply the principles and concepts of Smart to a given scenario to solve a problem using the knowledge you obtained in decision making.

Instructor hands out course critque AU Form 629 for students completion.

APPENDIX B

OVERHEAD SLIDES/GRAPHICS

COMPUTER-AIDED
DECISION MAKING

COURSE OBJECTIVE:

To improve decision making through a better comprehension of decision theory and decision models using a microcomputer.

- Demonstrate a general knowledge of decision making theory, decision models, and Decision Support System Concepts

- Demonstrate a working knowledge of the decision model used in this course

- Use the integrated software package (SMART)

- Use the decision model integrated with SMART to solve problems

COMPUTER-AIDED

DECISION MAKING

Eight lessons (16 hours)

Lesson 1

Introduction
Decision Theory

Lesson 2

Review
Decision Modeling
Decision Support Systems
Weighted Criteria Decision Model

Lesson 3

Review
Introduction to SMART

Lesson 4

Spreadsheet
Graphing

Lesson 5

Review
Problem A

Lesson 6

Problem A
Introduce Problem B

Lesson 7

Problem B

Lesson 8

Problem B Report
Review
Summary

OBJECTIVE

Demonstrate a general knowledge of decision making theory

DECISION LOOP

STEP 1: Become aware of problem

STEP 2: Define problem

STEP 3: Analyze alternatives & consequences

STEP 4: Select solution

STEP 5: Implement solution

STEP 6: Provide feedback

IMPORTANCE OF DECISION

Determines method

Size/Length of commitment

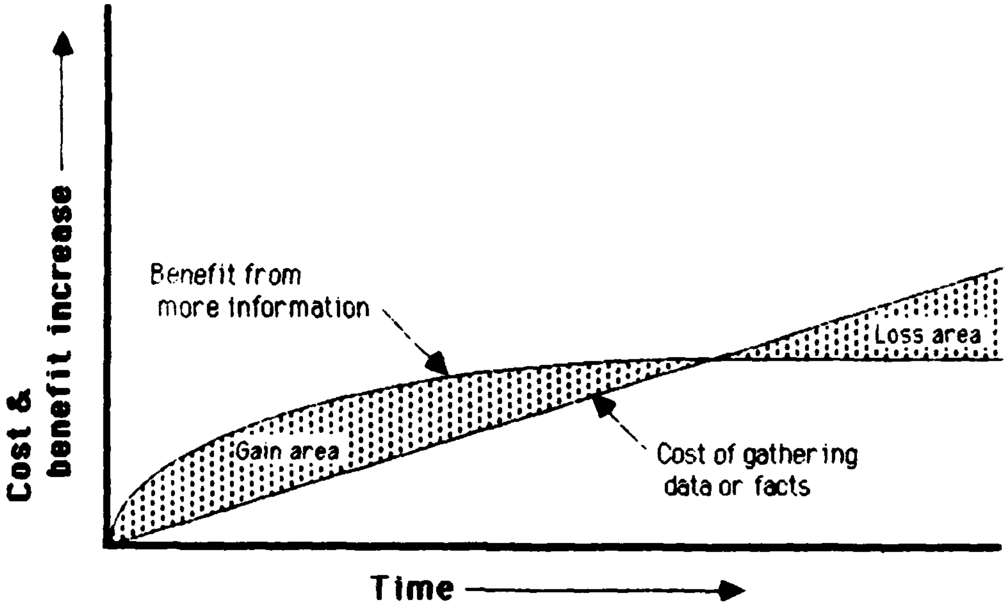
Flexibility of plans

Certainty of goals & plans

Quantifiability of variables

Human impact

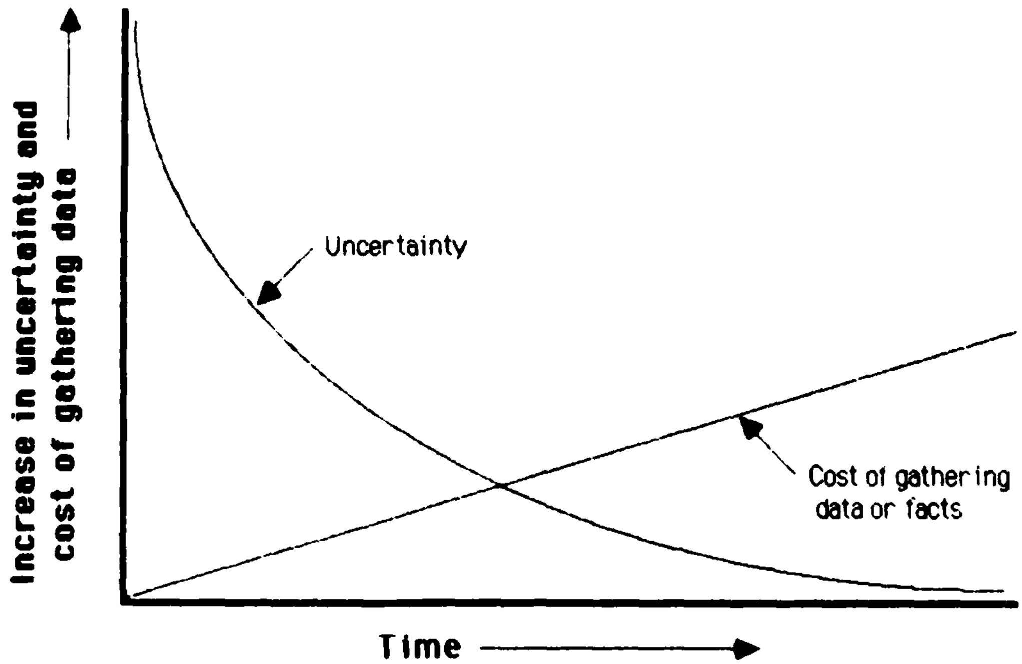
Cost-Benefit Time Curves



Moody, p 4, fig 2

1-6

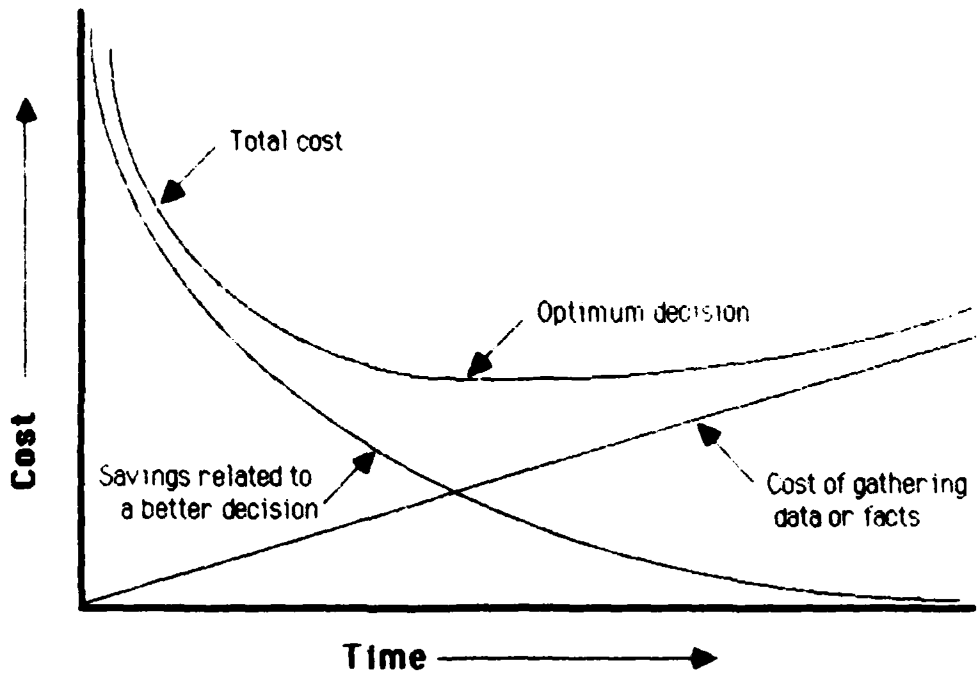
Cost-Uncertainty Time Curves



Moody, p 5, fig 3

1-7

Optimum Decision Point Curves



Moody, p 6, fig 4

1-8

DECISION INGREDIENTS

Facts

Knowledge

Experience

Analysis

Judgement

DECISION PROBLEMS

Misdirection

Sampling

Bias

Ubiquitous average

Selectivity

Interpretation

Jumped-at conclusion

Meaningless difference

Connotation

Status

GROUP DECISION MAKING

Brainstorming

Nominal Group Technique

Synectics

Consensus thinking

Delphi technique

GROUP DECISION MAKING

Advantages

- Broader background
- Spread of authority
- Special interest group
- Coordination of action
- Information exchange
- Span of authority
- Motivation
- Avoidance of action

Disadvantages

- Cost
- Compromise decisions
- Failure
- Guided decisions
- Committee responsibility
- Strong minority
- Management replacement
- Research
- Trivial decisions
- Authority

SUMMARY

I. Decision Theory

   A. How are decisions made?

   B. Decision Loop

   C. Importance of decision

   D. Time-cost relationship

   E. Decision ingredients

II. Non-mathematical decision making

   A. Individual

   B. Group

REVIEW

I. Decision Theory

A. How are decisions made?

B. Decision Loop

C. Importance of decision

D. Time-cost relationship

E. Decision ingredients

II. Non-mathematical decision making

A. Individual

B. Group

OBJECTIVE:

Demonstrate a general knowledge of decision models

WHY MODEL?

Necessity

Better decisions

Insight

Aid to presentations

Intuition

PROBABILITY

P X R = V

P - Probability

R - Reward

V - Value

Example:

Roll dice, get 7 or 11 win $100

Each try costs $2

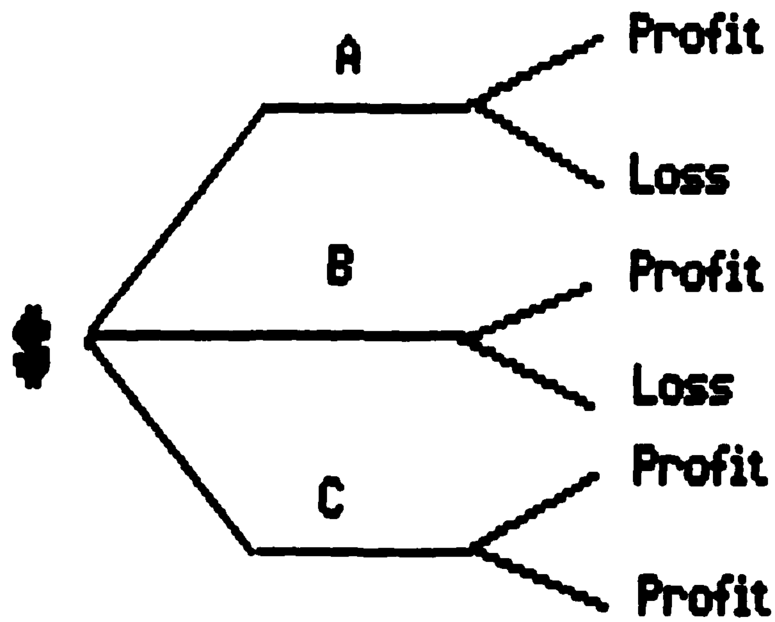
P = .17

R = $100

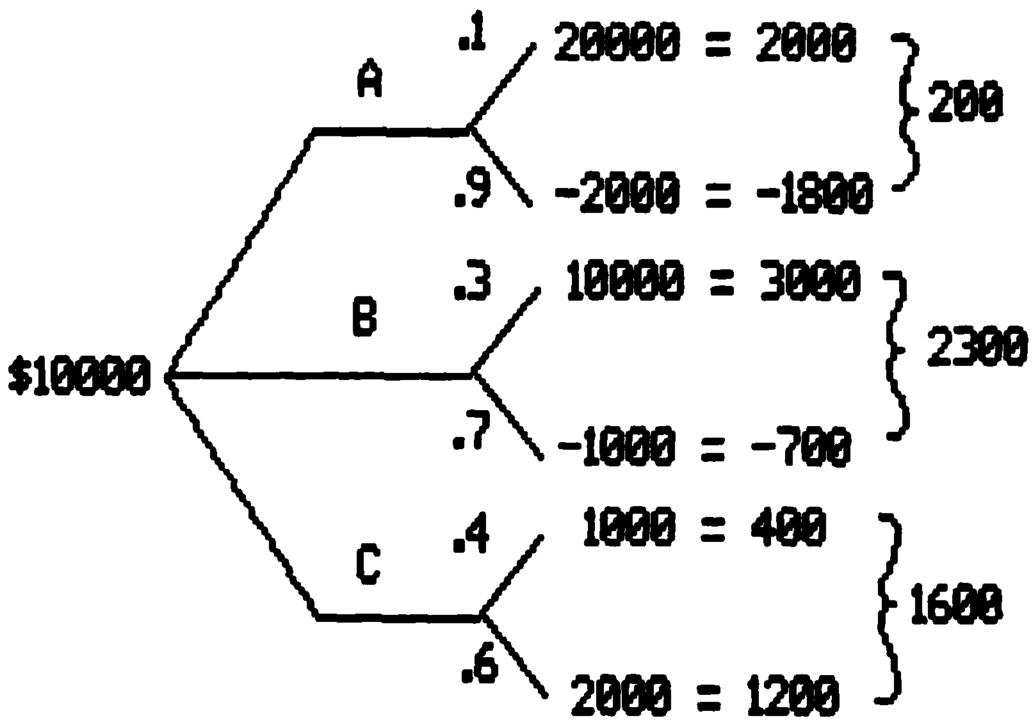
P X R = $17 (Value)

Value ($17) > Cost ($2)

DECISION TREE



RETURN ON INVESTMENT



OBJECTIVE

Demonstrate a general knowledge of Decision Support Systems

DECISION SUPPORT SYSTEMS

Pros

- Pre-programmed
- Fairly simple
- Advantages of modeling
- Uses computer

Cons

- Time consuming
- Garbage in = Garbage out

OBJECTIVE

Demonstrate a general knowledge of the Weighted Criteria Decision Model

WEIGHTED CRITERIA DECISION MODEL

Problem definition

Statement of purpose

Criteria definition

Criteria assessment

Alternatives

Weighting

Scoring

Analysis

Conclusions

CRITERIA ASSESSMENT

Car example:

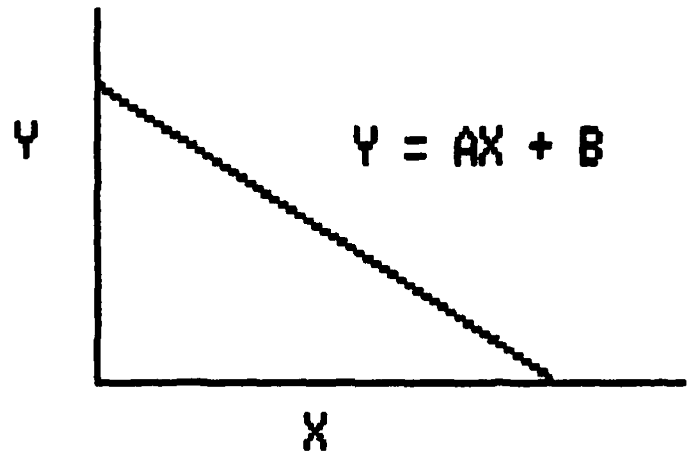
Criteria	Relative Value	Normalized Criteria Value
Cost	300	35.3 %
Gas Mileage	225	26.5 %
R & M	150	17.6 %
Seating Cap.	100	11.8 %
Trunk Space	50	5.9 %
Color	25	2.9 %
	----	-------
	850	100 %

WEIGHTING

Car example:

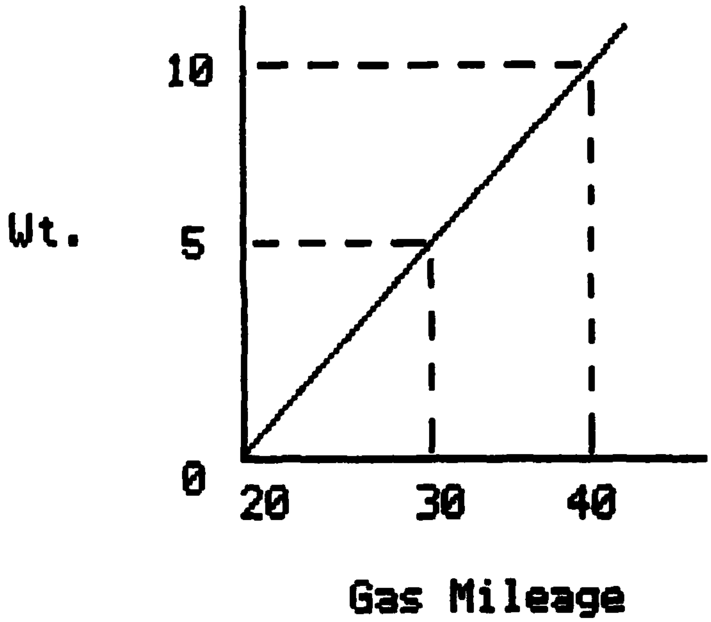
Criteria	Weight Limits
Cost	$12,000 - $16,000
Gas Mileage	25 - 40 mpg
R & M	Consumer Rpt/Subjecti
Seating Cap.	4 - 8 Pax.
Trunk Space	x - x Cu. Ft.
Color	Blue or White

LINEAR GRAPH



A - Slope
B - Y Intercept (X = 0)

WEIGHTING



$$Y = AX + B$$

$$A = 10/20$$

$$= .5$$

$$B = 0$$

If $X = 30$

$$Y = .5(30) + 0$$

$$= 15$$

SCORING

Car example:

Criteria	Criteria Value	Wt.	Score
Cost	35.3 %	5	176.5
Gas Mileage	26.5 %	8	212.0
R & M	17.6 %	3	52.8
Seating Cap.	11.8 %	0	0
Trunk Space	5.9 %	10	59.0
Color	2.9 %	10	29.0

		Total	529.3

SCORING

Car example:

Alternative	Score
A	529.3
B	480.7
C	505.8
D	450.6

ANALYSIS

What if I changed:

Relative Criteria Values?

- Importance of criteria

Limits on my criteria?

- Changes weights

How sensitive is outcome to the various factors?

REVIEW

I. Mathematical decision making

A. Why model?

1. Necessity
2. Better decisions

B. Examples

1. Probability
2. Decision Tree
3. WCDM

II. Decision Support Systems

A. Pros/Cons

B. Types

1. Computer-aided
2. Decision-modeling

III. Weighted Criteria Model

A. Problem Definition

B. Statement of Purpose

C. Criteria Definition

D. Criteria Assessment

E. Alternatives

F. Weighting

G. Scoring

H. Analysis

I. Conclusions

APPENDIX

APPENDIX C

STUDENT
HANDOUTS

Chapter 1

Introduction

DECISION LOOP

Often it has been asked whether organizations have any rules and regulations that relate to a process by which a manager can arrive at objectives, policies, and strategies. While there is no single set of rules for any of these functions, they all relate to decisions of different forms. Although a number of authors have tried to compile a concise list of rules to fit all cases, their attempts have been futile. However, a series of steps can be listed that relate to all decision-making circumstances. Figure 1 illustrates the closed-loop decision process.

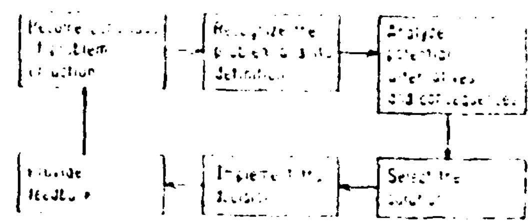


Figure 1 Decision-making loop.

The decision may be simplistic or complex, or it may relate to any of the other fields of management; however, all decisions can be guided by the basic closed-loop process.

IMPORTANCE OF THE DECISION

How are most decisions made? Are they made by guessing, by taking a poll, by voting, by following a hunch, by experience, or by a systematic approach to determine the best way to solve a particular problem? If this were a multiple-choice quiz, we would

Given that a number of methods can be used to arrive at a decision, how can we determine which one to use at a particular time? Obviously, this problem relates to the importance of the decision. For example, in an average business day, a decision as to which letter to answer first may be inconsequential, and so it may be made on a first-in, first-out basis. However, a decision related either to the selection of an individual for a major management position or to a significant capital expenditure would require significant prior research. Are there any guidelines to help determine the importance of a decision? Research indicates that there are guidelines for almost everything. Do we need them? The answer depends on the particular situation. In this text we provide these guidelines in a "cookbook" fashion for those times when they are needed. Thus the time required to read long-winded presentations of information (with the facts cleverly concealed) can be saved; instead, you can refer to lists that can be referenced with a minimum of digging.

The decision maker not only must make correct decisions, but also must make them in a timely manner at *minimum cost. The minor decisions* may not warrant thorough analysis and research and even may be safely delegated to others. The importance of a decision is strongly related to the decision maker's position in the organization. For example, a decision that may be of minor importance to a top executive may be of major importance to the individual making the choice at a lower level.

To assess a decision's importance, five factors should be evaluated:

1. *Size or Length of Commitment.* If the decision entails the commitment of considerable capital or the expenditure of great effort by a number of people, then it is considered a major decision. Similarly, if the decision will have a long-term impact on the organization, such as relocating a plant to a new or foreign site or getting into or out of a particular segment of the market, the decision is considered major.

2. *Flexibility of Plans.* Some plans can be reversed easily, while others have a degree of finality about them. If a decision involves taking a course of action that cannot be reversed easily, then that decision assumes major significance. An example would be the selling of patent rights for an invention that a company is not using presently but may wish to use in the future; another example would be the sale of a piece of land that is not being used currently. The financial consideration may be minor at the time of sale, but the long-term impact on the company may be significant.

3. *Certainty of Goals and Premises.* If a company has a long-standing policy of acting in a certain situation in a particular way, then it is easy to make a decision that is consistent with past history. However, if an organization is very volatile and a historical pattern has not been established—or if the nature of the decision is such that actions are highly dependent on factors known to only higher-level personnel in the organization – then the decision assumes major importance. For example, it would be quite inappropriate for financial directors to declare the amount of dividends to be paid based solely on their own financial data. They may not be aware of a capital expenditure that the company's top management has been considering while waiting for adequate profit data to justify the investment.

4. *Quantifiability of Variables.* When the costs associated with a decision can be defined accurately, the decision takes on minor importance. For example, if the method by which a component is to be machined must be chosen and if the cost and time associated with the use of each *method are known, then the analysis of relevant factors and the resulting* decision are not very important. But if the decision is related to bidding on the design and manufacture of a complex item and if the cost and program relate to a broad estimate which is subject to errors, then the decision assumes much greater importance.

5. *Human Impact.* Where the human impact of a decision is great, its importance is great. This is particularly true when the decision involves many people. As an example, I once worked in an organization that had two major facilities approximately 100 miles apart. To consolidate operations, it was decided to move one particular function from one location to the other. This may have been a fine plan; however, it did not take into account the fact that approximately 250 employees would have to either move or commute 100 miles. When top management finally realized the impact of the plan in terms of unhappy people and the potential of many of the best people for finding other employment, the plan was scrapped.

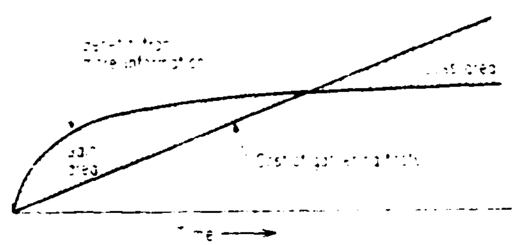
TIME-COST RELATIONSHIP

How do we make these final decisions? How much data do we gather first? How much does the data cost? Why can some people not make decisions even after great anguish over the alternatives? These questions relate to the individual's background, or experience, and education.

hough there is little we can do to change our personalities or our life, and we only have hindsight in relation to our personal ... we can do a lot about future life and educational experi... this text could be one step of an educational experience that will ... for the rest of our lives, for one primary difference between a ... and an "almost success" relates to an individual's ability to ... timely and good decisions, regardless of the complexity of the ... m or the decision maker's experience with it.

... s start by developing a definition of a decision. For the purposes ... text, a *decision* is an action that must be taken when there is no ... me for gathering facts. The problem is how to decide when to ... gathering facts. The solution varies with each problem we attempt ... for gathering facts costs time and money.

... 2 graphically elucidates the cost of gathering facts versus the ... its derived. In Figure 2, the more time expended gathering facts,



... 2 Cost-benefit time curves.

... greater the total related cost. Note that this loss may be felt in terms ... not only money but also opportunity, effectiveness of action, revers... of a decision, and so on. Also there is an immediate benefit from ... additional data to help us make the decision. However, as time ... the marginal benefit decreases until finally we have waited too ... The cost associated with gathering facts has outweighed the ben... that they provide. In essence, we move from a position where we ... gain by the accumulation of data to one in which we lose.

... type of chart varies radically for each decision; however, the principle remains unchanged. For example, the time required for a ... to take her hand off a hot stove may be quite dramatic relative to ... cost in terms of pain and the benefit in terms of the burn's severity ... conversely, a decision to sign or not sign a SALT agreement does not

have a similar short time frame, and much data gathering is required. But, even with a SALT agreement, too much delay may result in additional problems which could be more serious than we care to think about now.

If excessive gathering of facts is a risk, then why do it? The answer is evident. We gather facts to limit uncertainties about the results of the course of action we choose. For every decision made, there are varying amounts of uncertainty. Our task is to reduce that uncertainty until we are reasonably certain of the results of different options without exceeding the crossover point of cost versus benefit. An example of the relationship between uncertainty and the cost of gathering data is illustrated in Figure 3.

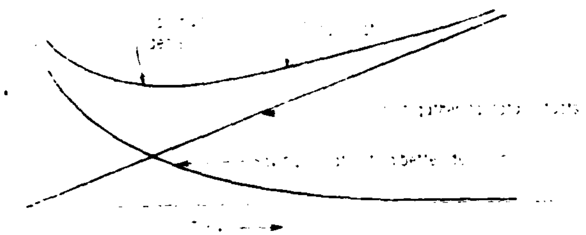
Figure 3 Cost-uncertainty time curves.

As previously illustrated, the cost of gathering data increases with time. However, as time passes and the amount of data gathered increases, uncertainty decreases. Note that uncertainty never reaches zero. So do we keep gathering facts until the uncertainty curve has flattened out? Not at all. By that time it is quite possible that we have passed our crossover point between cost and benefit and time has passed us by.

Now we are back to the beginning. How do we make effective decisions given that uncertainty will always be with us and that reducing this uncertainty entails a cost? The answer is to first analyze the problem and then evaluate its relative magnitude. For minor problems, off-the-cuff decisions may be completely proper. For decisions having major ramifications, the proper amount of data must be gathered to select the best course of action. Another way to look at the time versus uncertainty curve is to compare it with the curve of total cost of obtain-

...ing data to reduce uncertainty versus actual cost savings derived from ... additional data. See Figure 4.

...e point is that normally the total cost can be reduced by the ...roved decisions made after data have been gathered. However, at a ...ain point the cost of gathering data does not marginally improve



... 4 Optimum decision point curves.

...the cost factor associated with an improved decision. On Figure 4 this point is called the *optimum decision* point. Delaying the decision any ...ger results in a total increased cost, which may be in terms of actual ...lars, opportunity costs, or other factors.

ELEMENTS OF THE DECISION PROCESS

In *The Effective Executive*[1] Peter Drucker lists five elements of the deci... process:

1. Clear realization that the problem is generic and can be solved only through a decision that establishes a rule
2. Definition of the specifications of the solution, or the *boundary conditions*
3. Derivation of a solution that is "right," that is, one that fully satisfies the specifications before attention is given to the concessions needed to make the decision acceptable
4. The building into the decision of the action to carry it out
5. The *feedback* that tests the validity and effectiveness of the decision against the actual course of events

[1] Peter E. Drucker, *The Effective Executive*, New York, Harper & Row, Publishers, Incorporated, 1967.

Drucker goes on to explain that a decision is a judgment and, as such, is rarely a choice between right and wrong. At best, it is a choice between "almost right" and "almost wrong."

Clearly, decisions involve compromise; but I cannot agree that a particular set of steps can be followed to arrive at "almost right" conclusions. The reason is that almost all decisions are unique in character, controlling conditions, and preferred resolution. The best that any text can offer a manager or decision maker is, first, enough data to induce that person to consider the situation as a decision point, to recognize that a number of studies and investigations have been conducted which may provide guidance in arriving at the optimal decision, and, second, a single, readable (not high-powered) method of analyzing alternatives.

DECISION INGREDIENTS

The art—not science—of decision making is based on five basic ingredients.

1. *Facts.* In this text we discuss some methods of obtaining facts. Facts are gathered for both sides of the question, pro and con, in order to define the boundaries of the problem. However, if facts cannot be obtained, the decision must be based on the available data, which fall into the category of general information.

2. *Knowledge.* If the decision maker has knowledge of either the circumstances surrounding the problem or a similar situation, then this knowledge can be used in selecting a favorable course of action. In the absence of personal knowledge, we are forced to seek advice from those who are informed. Thus there has been a tremendous increase in the consulting business. In the 1920s and 1930s, a manager was expected to be familiar with all aspects of the business. However, this expectation has declined in recent years as business has grown more complex and individuals have specialized in areas in which a general manager could not be expected to possess technical knowledge, owing to the years of training needed. Obtaining consulting services is even more important when more than one speciality is involved in the analysis of multiple aspects of a complex problem.

3. *Experience.* When an individual solves a problem in a particular way and the results are either poor or good, that experience provides him or her with data to use in solving the next similar problem. If an accept-solution is found, most likely it will be repeated each time a similar ...em arises. If we lack experience, then we have to experiment, but ...when the results of a bad experiment do not have disastrous con... ...es. Major problems, though, cannot be solved by experiment.

... A great deal of the following text is devoted to methods of ...zing problems. These methods should supplement, but not ...e, the other ingredients. However, in the absence of a method to ...matically analyze a problem, perhaps we can study it by other mathematical means. If that fails, we must rely on intuition. Some ...ple scoff at intuition. But if the other ingredients of decision making ...t point to a direction to take, then intuition may be the only choice ...

5. *Judgment.* Judgment is needed to combine the facts, knowledge, experience, and analysis to select the proper course of action. There is ...substitute for good judgment.

DECISION CHARACTERISTICS

There are five characteristics of decisions. The first two are quite simi... to the factors used to evaluate a decision's importance.

1. *Futurity.* This characteristic involves the extent to which commit-ment entailed by the decision will affect the future. A decision that has ...ong-term influence can be considered a high-level decision, whereas a short-term decision can be made at a much lower level.

2. *Reversibility.* This factor relates to the speed with which a decision can be reversed and the difficulty involved in making that reversal. If ...eversibility is difficult, a high-level decision is indicated; but if revers-ibility is easy, a low-level decision is needed.

3. *Impact.* This characteristic relates to the extent to which other areas or activities are affected. If the impact is extensive, then a high-level decision is indicated; a singular impact relates to a low-level decision.

4. *Quality.* This factor relates to labor relations, ethical values, legal considerations, basic principles of conduct, company image, and so on. If many of these factors are involved, a high-level decision is needed; if only a few factors are relevant, a low-level decision is indicated.

5. *Periodicity.* This element relates to whether the decision is made fre-... A rare decision is a high-level decision, whereas a

DECISION PROBLEMS

The next topic to discuss is the 10 greatest problem areas associated with decision making. It may not be the best form to start a text with a series of lists. However, the purpose here is not to present data that should be taken as gospel, but rather to emphasize that many aspects must be considered in decision making and no one view represents the entire picture.

1. *Misdirection.* This is a case of wrong question, right answer. As an example, suppose you were looking for a top scientist to lead a group of highly trained technical personnel in search of a major breakthrough in some scientific field. You may find and hire the top scientist, only to have him or her lead the program into complete chaos and disorganized research projects. Perhaps you did not need a top scientist at all; what you needed may have been an individual with a scientific background and a record of success in getting technical people to work together to accomplish a joint objective.

2. *Sampling.* This problem involves the difficulty of securing a sample that is both adequate and representative. This is a constant problem in marketing, for an entire field of expertise has been developed to obtain sample sizes from a portion of the population which reflect what can be expected from the entire population. Although statistical analysis offers all sorts of probability curves and analytical data, there is the ever-present danger that the sample taken may not represent the facts. The most famous example of the danger of sampling is the major auto-mobile manufacturer that took samples to determine exactly what the U.S. public wanted in an automobile. The difficulty arose because what people claimed they wanted was quite different from what they actually wanted. The result was the Edsel.

3. *Bias.* This factor is the degree to which prejudice affects the answers. Although bias may be found in the decision maker, in a major decision the decision maker may well depend on information from a source hav-ing an unidentified bias. One example comes from my own experience when I applied for a position in a research laboratory at a particular salary. I was hired at the salary I requested; however, not until years later did I learn that one of my coworkers had recommended that I be offered a much lower starting salary. When I asked why, he stated that he thought I would ...

4. *Iniquitous Average.* Averages bury extremes, and these extremes may be very important. For example, assume you are considering going into a business which has a 10 to 50 percent profit on various items with an average return of 20 percent. You discover that you can expect your accounts receivable to be paid anywhere from 30 days to a year, with the average account being paid in 60 days. From the straight mathematics of the business, based on averages, it may appear to be a good investment. However, once into it, you may find that your low-profit items are paid promptly whereas collecting on high-profit items takes considerable time. This could force you to borrow capital to stay in business. The cost of the borrowing could change what appeared to be a good deal, based on averages, to a bad deal, based on reality.

5. *Selectivity.* This factor involves rejecting unfavorable results or choosing a method that is certain to yield favorable answers. The most common example of selectivity is a politician commenting on the results of primary elections. A candidate can lose 10 out of 12 districts in a primary and appear quite sincere when noting that the two *trend-setter* districts are indications that a groundswell of support is developing. Another example of obtaining a selective answer is the circulation of a marketing sampler that asks questions such as, Would you prefer to feed your children the higher-priced, yet nourishing breakfast food brand X or the lower-priced brand Y which has no nutritional value?

6. *Interpretation.* There is the danger in using facts and arriving at a distortion of their meaning. The most common problem associated with interpretation is simply the lack of technical background to understand what the facts mean. For example, the difference between a statistical and an actual sample could be expressed via the *mean*, the *median*, or the *mode*. If you were not familiar with the terms, you might think they all meant the same thing. In reality, they imply different things, and you may be considerably more interested in one than in the other, depending on the problem being evaluated.

7. *Jumped-at Conclusion.* You build it, walk into it, and spring it all by yourself. No one sets the trap for you. This is a simple trap to fall into, especially if you already favor a particular solution and the first bit of data substantiates your "gut feeling." Take the college professor who was correcting final examinations and happened to correct the class clown's paper first. The paper received a grade of 40 percent, so the professor immediately marked the class clown's report card with an F. What does the professor do after discovering that the 40 percent is the top grade for the class? Or there is the much more famous example of the embarrassed New York newspaper that ran a headline, following a Presidential election, that Dewey defeated Truman.

8. *Meaningless Difference.* A lot can be done to avoid this problem by practical experience. Suppose a company decides to invest considerable capital resources in buying an expensive computer system in which the staff has a considerable degree of capability and excellent technical background. In a field that changes as rapidly as the computer field, the technological edge of today may be completely meaningless tomorrow. So the option of renting computer services should be seriously considered before any large capital investment is made.

9. *Connotation.* This problem relates to an emotional content or implication that is added to an explicit literal meaning. Connotations can easily mislead the decision maker who is not aware of and watching out for them on a continuous basis. This emotional connection is used every day in advertising media. Take, for example, the names of models of automobiles. They imply romance, intrigue, speed, adventure, and so on. The story comes to mind of the boy who offered his little brother one *great big nickel* in exchange for two little dimes.

10. *Status.* In a business environment there is a barrier between a supervisor and a subordinate which limits communication in either direction. There is the fear of disapproval, on the one hand, and the fear of loss of prestige, on the other. This barrier can be low or high; however, the decision maker must recognize that it is always there and will have considerable impact on the data transmitted. In literally hundreds of conversations with both supervisors and subordinates, I cannot remember one in which one of us said, "Well, here is the data; however, it may be completely wrong."

SUMMARY

In this chapter we introduced the concept of the decision loop. Then we discussed how the importance of a decision relates to the speed with which we proceed through this loop. We also discussed factors that differentiate between an important and a routine decision.

Next we reviewed the cost of gathering data and the increase in benefits derived from this additional information. As more and more data is collected, the risk of uncertainty decreases. However, at a certain point the cost of gathering data does not increase the effectiveness of the final decision, and any further delay would pass the optimum decision point and increase total costs.

We talked about decision process elements as outlined by a prominent expert in the field. We supplemented this with a list of decision ingredients and characteristics. Finally, we listed 10 problems associated with the decision process that should be recognized and avoided.

CHAPTER 1

INTRODUCTION TO MODELING

This book is about creating and using decision models with the aid of a computer decision support system (DSS). For our purposes a *decision model* is any quantitative or logical abstraction of reality that is created and used to help somebody make a decision. It consists of quantities and their relationships. For example, if you were considering the purchase of a piece of real estate, you would project revenues and costs over the next 10 years and a residual value of the property after this time and then put this information together to help you assess what the property is worth. You may wish to express the relationship of revenues and costs to inflation and then investigate a variety of inflation scenarios. A decision model would contain all of your forecasts and all of the relationships among the variables. It would provide an estimate of the value of the property for any inflation scenario you may envision.

A DSS is the conduit for creating, revising, checking, and using the model. In its crudest form, the DSS may consist of a spreadsheet planning system, such as VisiCalc (or one of its many cousins), or an equation solver, such as TK!Solver. Most of the things you might like to do in using this book could be done reasonably well with even the simplest of such software.

The professional, however, will quickly develop an appetite for a higher level of decision-making support. Think of the complete DSS as a high level language that allows for natural, English-like expression of the model; that is able to access corporate and vendor data bases; that has easy-to-use graphics for displaying the results; and that contains powerful computational features for activities such as "what-if," sensitivity analysis, goal seeking, extrapolation, risk analysis, and optimization. In addition, think of the DSS as a system that supports the manager in treating ill-structured, messy problems and extends and enhances the manager's own understanding and judgment rather than providing a unique solution.

The examples in this book use the Interactive Financial Planning System (IFPS)[1], which has all of the features just mentioned in an easy-to-use package that runs on a mainframe computer. A companion package for the personal computer, IFPS Personal, is fully compatible with IFPS on the mainframe and will run most of the example models in this book. IFPS/Personal does not support risk analysis and optimization and it does not solve problems with the same rich variety of features available on IFPS.

Many other mainframe financial planning systems have features similar to IFPS, and the user of this book could use these systems to carry out the modeling tasks and develop models for the examples. The list of usable systems at the time of printing of this book includes the following:

System	Vendor
CUFFS	CUFFS Planning and Models, Ltd New York, N.Y.
EIS	Boeing Computer Services Co. Seattle, Wash.
Empire	Applied Data Research Princeton, N.J.
Express	Management Decision Systems Waltham, Mass.
FCS-EPS	Evaluation & Planning Systems, Inc. Houston, Tex.
Foresight	United Information Services Overland Park, Kan.
GSA GSM	Prediction Services, Inc. Manasquan, N.J.
IMPACT	MDCR, Inc. East Brunswick, N.J.
Model	Lloyd Bush & Associates New York, N.Y.
MSA FMS	Management Science America Atlanta, Ga.
Simplan	Simplan Systems Chapel Hill, N.C.
Stratagem	Integrated Planning, Inc. Boston, Mass.
System W	Comshare Ann Arbor, Mich.
XSIM	Interactive Data Corp Waltham, Mass.

There are many software possibilities on the microcomputer as well, too many to provide a complete list. In addition to the many cousins of VisiCalc and IFPS/Personal, the list of microcomputer software available at the time this book went to press would include:

[1] IFPS and IFPS Personal are registered trademarks of Execucom Systems Corporation of Austin, Texas

Software	Vendor
1-2-3	Lotus Development Corporation Cambridge, Mass.
Encore	Ferox Microsystems, Inc. McLean, Va.
MBA	Context Management Systems Torrance, Calif.
Multiplan	Microsoft Bellevue, Wash.
System W	Comshare Ann Arbor, Mich.
TK!Solver	Software Arts Wellesley, Mass.
VisiCalc	VisiCorp San Jose, Calif.

This is a book on modeling, not computer language, and it is intended for users of these other systems as well as IFPS users. In most cases the non-IFPS users will be able to understand the IFPS models easily and translate them quickly into the language of their own systems.

1.1 WHY MODEL?

You build a model to help you make a decision or to help someone else's decision. The help comes in two ways. First, the decision maker can respond to much more complexity than one person can easily grasp and resolve. Second, the model, through computer support, can keep track of many details and perform rapidly all of the computations. This allows the modeler to devote attention to judgments made about the individual details and composite results produced by the model.

1.1.1 Necessity

Models are built from necessity. They are done reluctantly when simpler approaches will not suffice. They are not a goal in themselves, even though they can be fascinating, almost seductive in pulling you from the decision at hand.

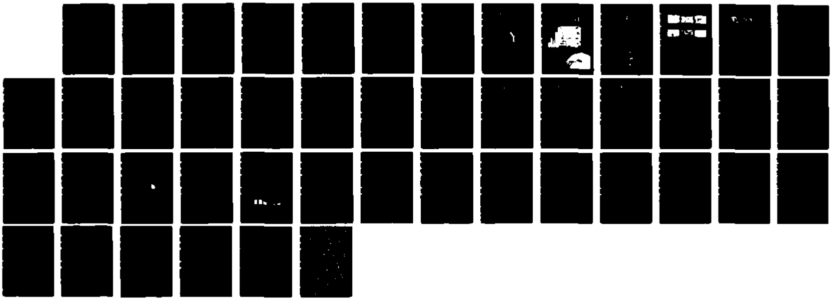
No one wants a model. People making decisions want the help that models can efficiently give. The model is not part of a goal—the decision is the goal. The model must be limited to a small effort relative to the importance of the decision. Low-stake decisions will be modeled only if they are repetitive or generalizable enough to be levered into a high-stake problem.

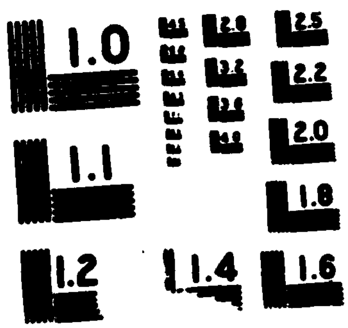
Learning to model requires adapting one's language in order to communicate the model and its results effectively. The medium with which to communicate models both to computers and to others is now provided by modern high-level modeling languages. This book adds other design and communication tools to aid the process of translating a messy problem into a model. While it is necessary for many people to become accustomed to new language and certain conventions of communication to create models, few people need to specialize in and study the language.

In this book computer language and mathematics are treated as English would be in a freshman English course: we all need to use English, but understanding language is not a goal in itself, as it might be for an English major. The modeler who is adept in a particular modeling language is like the writer of diplomatic communiqués. The translator can take pride in accurately rendering the subtlety of the subject. Yet neither the language nor the model is the end in itself; they are means to the end of better decisions.

AD-A194 210 COMPUTER-AIDED DECISION MAKING(U) AIR COMMAND AND STAFF COLL MAXWELL AFB AL M D DUTILLY ET AL APR 88 ACSC-88-0810 2/2

UNCLASSIFIED F/G 12/5 NL




1.0
2.5
2.2
2.0
1.1
1.8
1.2
1.4
1.6

1.1.2 Better Decisions

The model has helped you if you get a *better decision*. The decision can take into account more of the relevant facts and how those facts apply to the decision. The decision can deal with many relationships among things that influence the outcomes of interest. The decision can include the interaction of influences over a much longer period of time so that the decision does not just respond to the most obvious short-term considerations. The decision is better because the model has allowed a sensitivity analysis: The outcome has been studied as different assumptions are methodically varied. The impact of uncertain factors on the surety of results can be understood. The decision maker can understand which assumptions most affect the outcome.

1.1.3 Insight

A model gives you *insight* into your subject. You can explore the balances and tradeoffs among the factors that enter the decision. You learn the structure of the subject—the relationships among influences. It is useful to break a problem into pieces and put it back together in a model just to understand its anatomy. Diagnosis of other problems for which you do not build a model will be better because of this understanding.

1.1.4 Aid to Presentations

A model can be an *aid to presentations*. The model makes explicit the beliefs about interactions of aspects of the subject. Your presentation to the decision maker(s), or your depiction of your own decision, uses that structure. It shows your understanding of the problem as compactly as possible. You can concentrate on the important aspects, as shown by the results of modeling, rather than the obvious aspects.

1.1.5 Intuition

Complex systems behave nonintuitively. The model gives you insight into these nonintuitive behaviors that come from time lags between action and response, from interactions, and from the damping of one influence by another. The model provides *intuition about the whole*, starting with intuition about the parts.

The model tells you which gaps in your knowledge matter. Necessarily, you always work with incomplete understanding and data. Most gaps do not affect the decision much, but your model analysis tells you which pieces of information are important. This sets your agenda for research. If time and money allow, you know which areas of study will most improve the quality of the decision.

1.2 A MODELING DISCIPLINE

The model must be reliable. It must accurately reflect the assumptions of its builder. A disciplined development of the model is essential. The rest of this chapter describes such a discipline, one that works well. Subsequent chapters develop the elements of that discipline piece by piece.

1.2.1 Simplicity

The model must be kept simple, both to help make it reliable and to limit the investment in it. The model should be extendable. New influences may need to be taken into account and new questions may be asked about the subject matter of the model. Thus the process of model building recognizes two facts. First, the model will grow and shrink in future uses; thus the modeler must use tools that allow flexible editing. Second, a useful discipline for modeling cannot be described in terms of a flowchart. It is impossible to include all of the branching points in which it may be necessary to go back and redo a previous stage of the process or skip ahead to a later stage and work backward. Two important watchwords are *simplify* first-cut efforts to the bare essentials and *reconsider* any structure already applied to the problem in going on with the process.

1.2.2 Communication

A modeler must communicate with a computer that runs the model. This is the least important form of communication. More importantly, model builders communicate with themselves, through the model, about the structure of the subject that is modeled. The model must be clearly written so it can be quickly understood. This clarity also helps make the model reliable.

The model also provides communication to other people. It represents the embodiment of the beliefs of those who developed its structure; its clarity is essential.

1.2.3 The Manager's Roles in Modeling

A full appreciation of the specific purpose of the discipline requires an understanding of the relationships between the manager and the model. Throughout their careers, managers will work with decision models in three roles. The manager serves as model builder and *analyst*, as initiator and *user* of the model, and as the model's beneficiary or *client*. These roles are illustrated in the Stevens & Company case in this book. In that case a real estate firm that brokers large estates and agricultural properties is interested in modeling a large timber and farm property for prospective investors. The company engages a student of a master of business administration (MBA) program to carry out the modeling work. In this situation, the MBA student is the analyst, the broker is the user, and the prospective buyer of the property is the client.

While settings of problems may vary, these roles are generally identifiable in virtually all problems, although one person may play more than a single role. The Umeron cases illustrate the roles in a corporation, for example. A financial staff member is the analyst, the vice president of finance is the user, and the members of the new products review committee (senior executives) are the clients.

Typically, MBA graduates play the role of analyst more often in the early years following graduation. As they move up in the organization, they take on a greater portion of the user role (and have analysts reporting to them). As they become responsible for more and more decisions, they increasingly are clients with respect to the models.

Each role requires separate skills and an appreciation of the tasks faced by those in the other roles. As a user, the manager will learn to define objectives and performance measures for decision making, to structure the variables that will be used in the model, and to evaluate and use the support offered by the model. As an analyst, the manager will learn how to write the model; how to carry out the assessment of numbers needed in the model; how to conduct an analysis of any combination of certain, risky, and time-dependent variables; and how to communicate to supervisors the work done on the model. In both the user and the analyst roles the manager will need to know how to present the model design and results to clients. As a client, the manager will learn to *evaluate* and understand the work of others and learn appropriate ways to *intervene* in the modeling effort.

The skills necessary to be effective in each of these three roles are developed in this book. The discipline of modeling is described assuming the reader is interested in learning all three roles. Indeed, in many of the cases in the book, proper understanding of the situation and the appropriate tasks to carry out requires that the problem be examined from the perspective of each role.

1.3 GETTING STARTED

Managers often have the greatest difficulty knowing how to start a model. Their problems m appear to be huge and untidy, and they may have little confidence and experience in creat a model. Thus a major focus of this book is model structuring.

How do you start modeling? First, understand the decision that is to be made. This soun simple, but very often a problem is so complex that no one has clearly stated what they a trying to decide. This phenomenon was illustrated vividly to me in working with executiv on a new-product-development problem. Although this was a big project on which many peo had already done a lot of planning, I could not get them to tell me what the decision to made was. It might have been a go or no-go decision on the product, or it may really ha been a product redesign question since the commitment to the product in some form appear firm. Although a lot of time and work had already been spent on the problem, no one was su exactly what the decision was to be made and what were the available alternatives. In t case, a little time spent defining the questions at the outset could have saved an enorm amount of time later.

Finding the objectives to be achieved in making the decision is not always obvious or impli in the decision. Make sure what is being maximized before creating a model to decide how do it.

Chapter 2 presents ways to define decision variables, to establish the objectives of decis making, and to identify attributes associated with the objectives. A key contribution of t material is the assurance that it can give the modeler that the objectives of the decision mal can be translated into attributes that measure the degree of achievement of the objectives.

Having identified the variables of a model, the next step is to decide how these variab relate to one another. Chapter 3 presents tools for structuring a model design from the variabl The *influence diagram* displays all variables, and arrows running from one variable to anot indicate the direction of influence. Variables that are assumed to be known with certainty a distinguished from those that are uncertain.

The diagram also uses three distinctive types of influence. The simplest influence is o where the level of one variable determines the level of another variable with *certainty*. *random* influence implies that a variable only partially affects the level of another and unpredictable effect also partially determines the level of the influenced variable. The final ty of influence is a *preference* influence, wherein the desirability of an attribute is influenced another variable or attribute.

The step of creating the influence diagram is the most important one in establishing t framework of the model. Often you find a "major" influence is not linked to an attribute at a When this occurs, demote it to a minor consideration to be handled outside the model. Sometim holes in the influence diagram indicate that intermediate variables are missing. Not only do the finished influence diagram make you ready to get down to the nitty-gritty of writing t model, it is the most convenient form for presenting the model to others.

1.4 CREATING AND USING A MODEL IN A HIGH-LEVEL LANGUAGE

The next step is to decide on the form of relationship for each influence. Keep relationshi simple, there is no prize for introducing the most unusual mathematics. Later steps of t modeling discipline will revisit these choices and you will have an orderly way to improve t ones that matter.

This does not mean that within the bounds of simplicity and conciseness the model sho not be as accurate a representation of reality as possible. The modeler needs to become famil with the wide range of possible relationships among variables that may be expressed in ord to create realistic models. Chapter 4 describes a menu of mathematical functions to use expressing a relationship between a dependent variable and one or more influencing variabl

The examples use the features of IFPS but the modeling capabilities are available on most high level planning or modeling languages. Most relationships can be produced with a little effort even on microcomputer spreadsheet planning software.

Random variables are modeled with a menu of available probability distributions. When random variables are used, the models are solved using the technique of Monte Carlo simulation (described in Chapter 5) in order to see the uncertainty in the attributes.

Chapter 5 describes how to complete the model to obtain preliminary results and then how to improve and validate the model. After checking the pieces of the model, you test the accuracy of the model in its composite form. A first-cut run of the model is the place to begin.

What-if exercising helps in understanding and verifying the model and provides answers to decision questions. Sensitivity analysis continues this process, revealing the significance of intermediate variables in determining attribute levels. Use this understanding to decide if and how to extend the model.

At this stage, you can test specific goals using the model. For example, you can check whether it is possible to attain some target level of performance on a specific attribute. This begins to move the problem from the realm of what if to the realm of "what's best." A what's-best analysis requires evaluating the relative desirability of alternative levels of outcome attributes. This raises questions of how to treat multiple objectives and uncertain attributes.

1.5 INCORPORATING DECISION PREFERENCE INTO MODELS

Chapter 6 describes the major ways to make choices accounting for multiple objectives. Starting with dominance and other approaches that do not require tradeoffs among attributes, the chapter goes on to describe procedures for weighting attributes. These procedures are easily incorporated directly into a model.

Chapter 7 provides the modeler with methods for incorporating attitude toward risk into the model. An important aspect of the approach of this chapter is the discussion of how to treat risk when one is modeling corporate risk preferences, where there is no single person to express attitude towards risk.

The modeler may want a more realistic model of preferences than was provided in Chapter 6. In particular, it may be necessary to treat interactions among attributes and nonlinear values for attributes. For example, an attribute such as square feet of space in a model to help in choosing a home may be such that its value is nonlinear. That is, the value of an additional 100 square feet of space may decline as the size of home increases. Preferences for this attribute may interact with another variable or attribute. For example, the location of the house may greatly affect the desirability of various home sizes. These issues are treated in Chapter 8. Besides discussing the implications of the various preference models, the chapter gives guidance on assessing preferences.

The final two chapters deal with specific application problems. Chapter 9 shows how to use models for group decision making. The principal application of this would be to the committee decision problem, but more general collective choice problems and bargaining problems are considered. Voting rules, scoring rules, procedures for achieving consensus, and group preference functions are presented and incorporated into decision models.

Chapter 10 treats issues that arise when modeling risky projects that stretch over significant amounts of time. Several approaches are described. The discussion then centers on when and why each possible approach should be used.

The discipline developed in this book will prepare you to take an unstructured problem, decide on the important variables and attributes, structure influences among these variables, apply your own or a group's preferences to them, exercise the model, and make a decision. What is then needed is familiarity with a wide range of applications and some experience developing models in a decision context. The cases making up the rest of the book provide this opportunity to internalize the discipline.

1.6 USE OF CASES AND EXERCISES

Cases are organized by functional or application area as shown in the table of contents. No theless, the cases are intended to develop specific modeling skills. Assignment questions develop those skills are given for particular cases at the end of each chapter. Some cases integrative: no assignment questions are given for them. A principal component of learning create a model is developing judgment about what is the major modeling task. Thus the diagno of what to do with the integrative cases is a key part of the learning that comes from cases

Clearly, the learning that will come from the kinds of cases in this book will be enhanc by classroom discussion. Where this is not available, discuss the problems with colleagues. use the cases to identify similar problem areas in your own area of responsibility. Work thro these personalized cases as you read the chapters.

With each chapter are exercises. Spend some time with these as you read the chapters. So of the exercises have sample solutions at the end of the book. Recognize that few of th

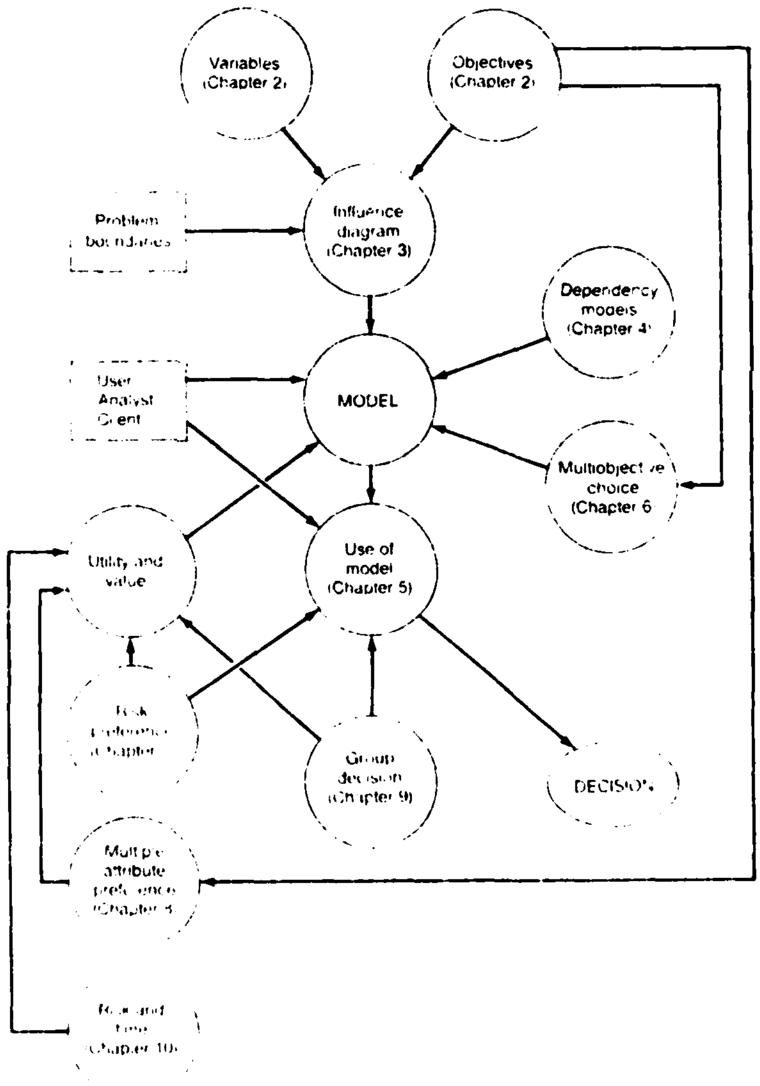


EXHIBIT 1.1 Influence diagram of the modeling discipline and the book's organization

exercises have a single right answer, and these solutions should serve only as guides. Complete the work you intend to do on the exercise before flipping to the back of the book. Clearly, the value of the material for the nonclassroom user is tied to the degree of self-discipline you can muster to work through the exercises and use the cases along with the reading of the chapters.

1.7 SUMMARY

What book on modeling would be complete without a *model* of its conceptual design? The best way to express the essence of a model in a nutshell is through an influence diagram. Thus it is appropriate to end this chapter with an influence diagram of the book and its associated modeling discipline (see Exhibit 1.1). Undoubtedly, this exhibit will shed more light on the schema for the book after the material on influence diagrams in Chapter 3 has been read. It would be wise to look at the exhibit briefly now, then refer to it after reading Chapter 3 and later.

The rectangles in Exhibit 1.1 represent choices made by the modeler outside the modeling process. The modeler must decide what are the boundaries of the problem and who will play the roles of user, analyst, and client with respect to the model. Circles refer to variables in the modeling process, or in other words, the component tasks faced by the modeler in reaching the ultimate goal of making a decision. Note that these tasks center on the model of the problem itself. Of course the ultimate measure of the value of modeling is the *decision*, represented by an oval.

KEY TERMS

decision model	simplify – reconsider
better decision	roles in modeling: analyst, user, client
insight	modeling discipline
aid to presentation	
intuition about the whole	

EXERCISES

1.1 Why are you interested in this book? What are your typical modeling tasks? What role(s) do you play in these modeling tasks—analyst, user, or client? Select two or three of these tasks to think about as you go through this book.

1.2 Based on your prior experience with quantitative modeling, assess your own philosophy of modeling. Make a few notes on the process of going from problem to model to decision. How does it compare with the ideas in this chapter?

Decision Support SOFTWARE

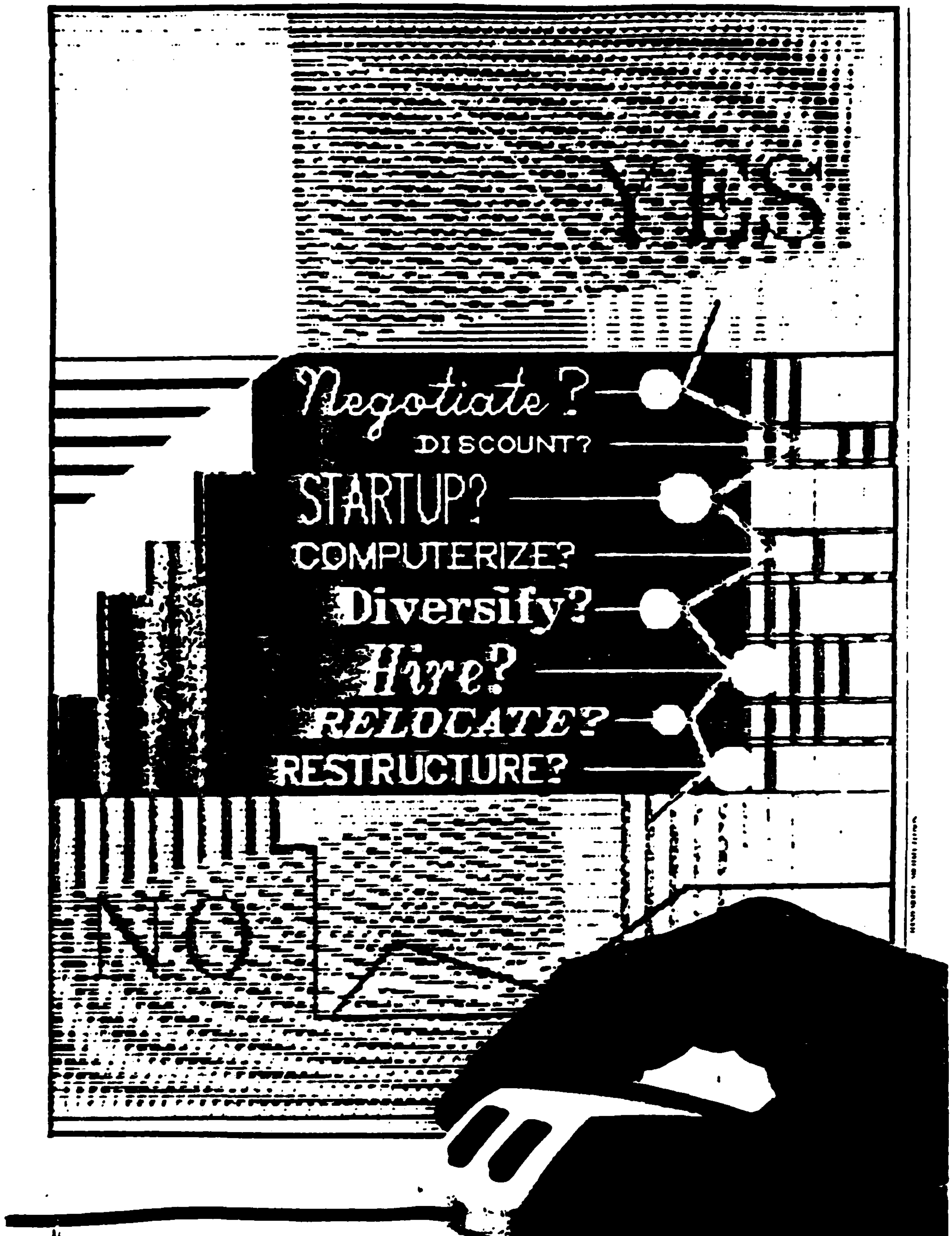
SPECIAL REPORT

Programs that help you weigh risks and marshal facts really can improve your business decisions

YOUR mission was to take that modest budget and, in the entrepreneurial spirit promoted by the top executives at *your* company, originate and implement your own projects. You and your management team did just that, several times, in fact, and did it well, with a few dollars to spare. Indeed, the team feels it has the Midas touch; during its last meeting, one of your people suggested developing a new product to introduce in a hot market. You are mildly in favor of the idea but also apprehensive about the possible need to divert capital from ongoing projects or have the team's winning streak snapped by an underfunded venture. You decide to discuss it at Monday's staff meeting.

At the beginning of the meeting, many people share both your moderate enthusiasm for the idea and your misgivings about putting an added strain on limited resources. As you discuss pros and cons, however, you realize that everyone has become increasingly enthusiastic about the likelihood of yet another successful project by the company's all-stars. Finally you agree to commit your team and the company's money to it. It's a decision you live to regret.

BY CHARLES SPEZZANO



Computer Illustration by Marilyn Ono/Photograph by Mike Blake

Six months later, the new product is still not ready to ship, despite your having convinced your division head that it would be, and you are pessimistic about your company's chances of getting its anticipated share of the market. Worse, you are unable to fully develop two of your other projects as successfully as you might have if you had concentrated your energy and budget on them instead of taking on this new brainchild.

The promotions you thought were almost certain for you and several key players on your management team seem much less likely now. You remember that when the new project was first proposed you worried that something like this might happen and now wish you hadn't ignored your original misgivings.

Can decision support software (DSS) help you avoid a costly decision like this? After reviewing 10 of the leading DSS packages and weighing that evidence along with expert opinions and a desktop full of books and articles from the growing literature on business decision making—in light of what psychology has come to understand about human beings struggling to decide—the answer I arrived at is a qualified yes.

Indeed, each of the decision support software programs covered here can help managers in situations like that in the above scenario, albeit in different ways. And if the software is fed the right information, it can help push you and your managerial staff toward more cost-effective choices.

Some DSS programs help you weigh the risks more dispassionately, while others marshal financial facts into more accurate forecasts. None of them makes the actual decision for you, and all of them can be consciously or unconsciously misinformed by you to reach the decision you want them to reach. Furthermore, it takes time to get the necessary information into the computer before any DSS program can do anything productive; for the proper use of some of them, the time frame is weeks of data entry. So if you're in a big hurry, you may have to go with experience and intuition rather than electrons. There is no magic in DSS, but there's potential for significant help in making your business decisions.

What follows is a compact but thorough tour of the questions surrounding decision support software, beginning with the psychology of decision making—not only because it's my home field but also because it provides the best backdrop for understanding how computer programs can help people make decisions. A description of the two major categories of DSS programs comes next, along with comments on the leading contenders in each and examples of their use in real-life business situations. Capsule summaries of available DSS programs worthy of consideration begin on page 60.

Psychologists ask: why do people become 'polarized,' or more extreme in their views, when trying to reach consensus in a group discussion?

Group Dynamics

A student of modern social psychology would have guessed that the group decision in our opening scenario would encourage you to take that unfortunate plunge. Once upon a time, however—as recently as 25 years ago—psychologists believed that groups were almost always more conservative than individuals in their decision making. But the first attempts to test this wet-blanket effect quickly cast doubt on it. In fact, initial studies in the early 1960s suggested that as groups discuss decision alternatives they tend to get excited about taking the riskier course of action. The idea that this might be an almost universal tendency among groups led social psychologists to attach a nickname to the phenomenon—the "risky shift."

Alas, this theory did not hold up under further investigation, either. Other groups got more cautious as discussions progressed. The contradiction turned out to be the other side of a coin that may well reflect a universal group tendency—the tendency toward "polarization" in decision-making discussions. From juries and panels of judges to groups involved in bargaining and negotiating, individuals within groups tend to become more extreme in the views they started out with than they were before the discussion.

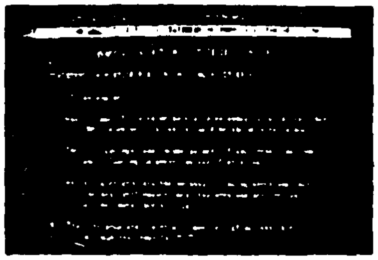
Why? Some psychologists speculate that, as we realize that a particular position or attitude is the one favored by the group, we tend to embrace it even more fervently than when we thought it was just our own opinion. Others argue that although everyone starts out leaning to one side or another, individuals may favor the same choice for different reasons. Then as the discussion proceeds, we add the arguments of the

---

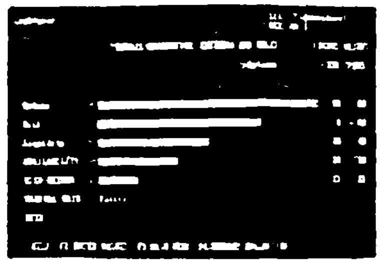
Charles Spezzano, Ph.D., is a Denver-based clinical psychologist who writes regularly about microcomputers. He is also the founder of the Society for the Prevention of Cruelty to Users.

DECISION-AID PACKAGES

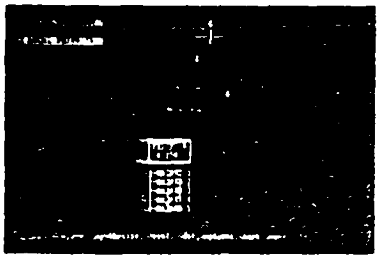
Decision Aids suggests a hierarchy of options based on weighted critical factors. ($250, for IBM PC, XT, AT, and compatibles, HP 150, and DEC Rainbow 100 with 128K and DOS 2.1 or greater; Kepner Tregoe Inc., POB 704, Princeton, NJ 08542, (609-921 2806)



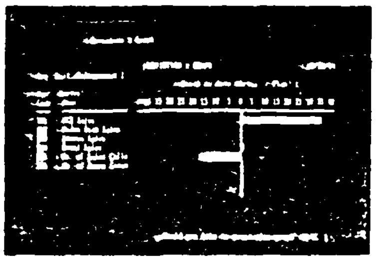
Decision Analyst suggests a hierarchy of options based on weighted critical factors. ($139, for IBM PC, XT, AT, and compatibles with 128K or any MS-DOS computer, versions for CP/M-86 [128K] and CP/M-80 [56K]; Executive Software Inc., Bay St., Shanty Bay, Ontario, CD L0L 2L0, 705-722 3373)



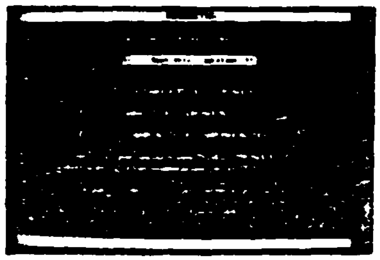
Lightyear suggests a hierarchy of options based on weighted critical factors. ($495, IBM PC, XT, AT, and compatibles with 192K and DOS 2.0 or greater. Lightyear Inc., Suite 301, 2465 East Bayshore Rd., Palo Alto, CA 94303, 408-985-8811)



Expert Choice, based on a decision-tree model, helps you assess intermediate decisions in reaching a stated goal. ($495, IBM PC, XT, AT, and compatibles with 256K and DOS 2.0 or greater. Decision Support Software, 1300 Vincent Place, McLean, VA 22101, 703-442-7900)



Trigger is a decision control and monitoring system based on predetermined limits. ($495, IBM PC, XT, AT, and compatibles with 128K and DOS 2.0 or greater. Thoughtware Inc., Suite 1000A, 2699 S. Bayshore Dr., Coconut Grove, FL 33133, 305-854-2318 and 800-848-9273)



The Decision Maker is a decision control and monitoring system based on predetermined limits. ($250, IBM PC, XT, AT, and compatibles with 128K and two disk drives; Alamo Learning Systems, Suite 600, 1850 Mount Diablo Blvd., Walnut Creek, CA 94596, 415-930-8521)

others in the group to the ones we had already thought of to bolster our position.

No matter which explanation for polarization is correct, the likelihood that groups may not help the individuals in them move toward a balanced and well-reasoned position has strong support from a host of researchers in social psychology.

Gut-Level Decisions

The study of groups is not the only psychological perspective from which to view the decision-making process. Psychologists have been aware for half a century that individual decision making follows a definite pattern. Once we become immersed in the facts, ideas, and techniques of a particular situation, we sit back and allow those collected experiences—including related conversations in hallways and washrooms—to incubate. Whatever happens in the gray matter of the brain and in the gut during that incubation period is beyond anything a computer can currently do. All that has been assimilated undergoes a transformation, and a new way of seeing or doing something emerges.

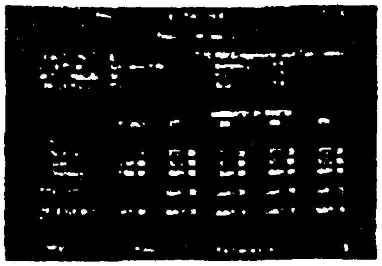
However, we can't be sure that our new vision will accurately reflect reality. Recent studies clearly show that our personal view of a situation will strongly influence our decision even when we are striving for a solution based on a rational analysis of the facts. Because all decisions involve judgment in the face of uncertainty, we unconsciously fall back on a variety of decision-making principles that defy the laws of probability. We may look for a course of action that matches our mental model of how things should be. We may overestimate the likelihood of dramatic events and underestimate the likelihood of less dramatic, but more common, happenings. Or we may make risky decisions to avoid losses rather than to achieve a gain because, psychologically, losing something we already have hurts more than not getting something we want.

In the face of such a complex psychological picture, keep in mind these two critical questions as you're considering a DSS program to help with business, professional, or personal decisions. First, is the software likely to compensate to any significant extent for the psychological limitations of human decision making? Just as important but rarely considered is the flip side of that question: might the introduction of a computer cancel the often overlooked positive contributions of emotion, intuition, and experience to the decision-making process?

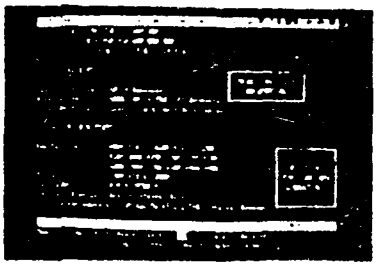
Two Types of Programs

Two varieties of software huddle together under the DSS umbrella: decision-aid packages and decision-modeling packages. Decision-aid pro-

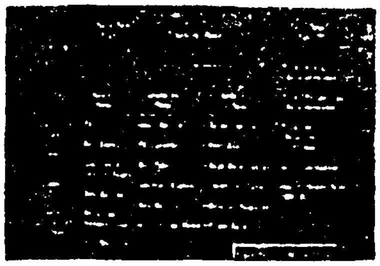
DECISION-MODELING PACKAGES



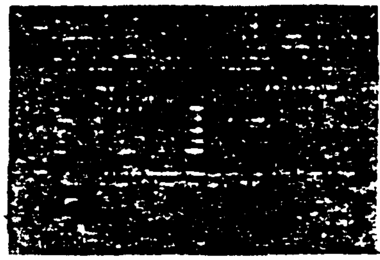
MAC-PAC/PC builds models designed for top management, sales and production planning and financial [illegible] all of which generally [illegible] tactical and technical rather than strategic decisions. Twelve-month sales and production plans entered [illegible] management [illegible] [illegible] [illegible] [illegible] IBM PC, XT, AT [illegible] [illegible] Arthur Andersen & Co. [illegible] Congress Ave., Austin, TX [illegible] 496-3700.



IFPS/Personal also comes into play primarily at the tactical level. For example, when you know your goal—a strategic decision—its goal seeking feature optimizes your results. Sophisticated "what if" interrogations provide high-level analysis of a wide variety of possible situations that will help determine negotiating tactics and budget allocations. ($895) IBM PC, XT, AT and compatibles with 512K RAM and DOS 2.1 or higher. Execucom Systems Corp., 3410 Far West Blvd., Austin, TX [illegible] 512/346-4[illegible]



Encore is aimed at managers and executives seeking to develop complex financial production models. It handles such advanced applications as goal-seeking analyses and linear regression models but requires mastery of a procedural language that may prove difficult for users unfamiliar with a programming environment. [illegible] IBM PC, XT, AT and compatibles [illegible] [illegible] hard disk [illegible] Arlington, VA [illegible]



The Confidence Factor spreads itself out over most of the categories defined in this article [illegible] less attention paid to technical decision making than the other types [illegible] a management team from initial analysis of strategic options through [illegible] resources. For example, the Harris Feeding Company in Coalinga [illegible] used The Confidence Factor [illegible] a hardware manufacturer to supply [illegible] [illegible] [illegible] [illegible]

[illegible]

Decision-Aid Programs

Decision Aide from Kepner-Tregoe Inc. takes you through the entire decision-making process using the widely taught Kepner-Tregoe "rational management" decision analysis technique. First you pose and state the problem. Then you establish objectives and categorize them as "musts" or "wants"—in the opening scenario, for example, maintaining the current terrific profit margin might have been a "must" for the management team, while capturing a small share of a lucrative new market might have been only a want. The next step is to generate and evaluate alternatives [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] alternatives. The [illegible] [illegible] alternatives that [illegible]

[illegible] are discarded [illegible] [illegible] with the [illegible] and [illegible] significant adverse [illegible]

Decision Analyst from Executive Software [illegible] Decision Aide. Its main menu [illegible] you [illegible] define the problem, state the objectives of the decision, define your criteria, sort and list the criteria, define your alternatives, weight [illegible] alternatives [illegible] [illegible] for example [illegible] of the new product will [illegible] [illegible] months [illegible] market [illegible] [illegible] The manual [illegible] CP/M version of the [illegible] pages added [illegible] number of MS-DOS users.

Eight-year [illegible]

gers and professionals will at least find slick, easy to use, and probably fun to play with. It allows you to place any number of variables into a matrix, assign numerical or subjective weights (good, better, best, for example), then derive a rank order of those variables based on the weights you have assigned. When the group making a decision is forced to rank its priorities, passionate rhetoric is less likely to steer the deliberations down a seductive dead-end street. Lightyear also allows you to specify logical relationships and then use those logic statements to analyze your decision variables. It has attractive graphics capabilities, unlike Decision Aide, which has none, as well as handy pull-down menus and a well-designed user interface.

In addition to the standard weighted-factors features, Lightyear allows you to continually add variables as you think of them, weight them as you desire, add logic rules, change your mind, and then get a graphic representation of your decisions. Like Decision Aide, it can be especially helpful to a managerial group struggling with a decision that involves too many variables to be juggled mentally. As one user put it: "It was the synergy of the group process which I found most useful. This synergy was created, in part, by being around the computer and having questions answered immediately and seeing the results of weighting changes right after they were made. Among all the decision-making meetings I have held over the years, in the one using Lightyear the decision was reached most easily and the meeting was more enjoyable than any other."

Expert Choice from Decision Support Software is another of the many programs that fit into some corner of the broad decision-aid category. Expert Choice provides a tree structure with the overall goal at the top and key criteria that will determine the final choice branching off from it. The leaves on these branches represent the actual choices. Based on a somewhat jargon-laden system called the analytic hierarchy process, Expert Choice has you make paired comparisons of the "decision nodes" at each level, two at a time, using either a verbal or numerical scale.

Our mythical manager might, for example, have viewed cash flow and market share as two key branches. He could then use Expert Choice to draw out the implications of staying on the strong and steady branch he currently occupied with three successful projects versus going out on the limb that ended up being sawed off behind him by better-funded competition and inevitable delays in product development. Then the final report would have shown the relative merits of each leaf (three birds in the hand versus one in the bush) on the tree.

Decision-aid packages help you evaluate business options by assigning weighted values to each factor. But will people really take the time to use them?

Trigger from Thoughtware Inc., by contrast, is on the boundary between decision aids that help you figure out which path to follow and management aids that help keep you on track once you have set a course. It lets you set upper and lower bounds on important criteria that will become triggers—a sort of automatic decision switch—to initiate a particular action under certain circumstances. For example, you can set up high and low ranges for things like sales in certain districts or quality control limits. If the actual events fall outside the ranges you can live with, then a specific action gets set in motion, like a letter to the head of quality control or a memo to the district sales manager. If everything is working within the acceptable limits you defined, nothing happens.

The Decision Maker from Alamo Learning Systems is somewhat similar in style but geared more toward initial decisions. It establishes criteria that are either considered "limits" ("must-pass" tests) or "desirables" that are numerically weighted and scored.

Do They Work?

At what point in the decision-making process might any of these decision-aid packages have aided the manager whose struggle opened this article? There are two possibilities. If he had, in private, heavily weighted certain factors such as the consequences of using available funds to hire new sales and production people for the ongoing projects, then any of the decision-aid packages might well have pointed to the decision to avoid the new venture as the most reasonable course of action.

If the manager had taken a decision-aid program into the meeting with him and used his personal computer as a sort of electronic blackboard—a substitute for standing in front of a chalkboard and drawing arrows between different options—the process of quantifying the fac-

—*Continued on page 122*

Continued from page 61—
tors might have made it harder for people to talk themselves into ignoring the well-known failure rate of new ventures and weighing more heavily the benefits of bolstering an amazing string of consecutive successes.

Decision-Modeling Programs

If you want the help of a personal computer in making such strategic, direction-setting decisions about whether to accept a mortgage at 12½ percent or wait to see what happens to the rates next week, or whether your company should enter a new market or develop a new product, then you could benefit from a decision-aid package. If, on the other hand, you have already decided where you want to go and now you need help in determining the best tactics and plans for getting there—for example, you have decided to introduce a new product but are struggling with alternative sales and production plans or questions about budget allocations and personnel assignments—then decision-modeling software may better suit your needs.

Spreadsheet users are familiar with the financial-analysis and forecasting capabilities of spreadsheet software. When it is used that way, a spreadsheet is, in a broad sense, a decision support program. Spreadsheets can manipulate numbers and formulas well enough to accomplish some of the tasks that decision-modeling packages handle. But for many sophisticated modeling and analysis applications, such as those requiring goal seeking and simultaneous equation solving, spreadsheets are in over their heads.

The decision-modeling packages discussed here can handle complicated dependencies and circular references within chains of formulas better than spreadsheets can. Some decision-modeling packages allow larger and more complex models to be developed because they break things down into more manageable parts. For example, the data and relationships may be stored in separate files while the main worksheet is left free for a bird's-eye view of only the results. Because of these added capabilities, decision-modeling packages often let managers lay out business problems in more understandable terms than they can with spreadsheets.

A Case in Point

Let's take a look at a decision-modeling program in action to see what this type of software can do under the right circumstances.

ONCE YOU have decided where you want to go, decision-modeling packages can help you determine the best tactics and plans to get there.

When John Blight took the position of chief financial officer and director of manufacturing at United Air Specialists, a $20-million Cincinnati company specializing in pollution-control equipment, he found a lack of coordination between sales, production, and operations. That's not as dramatic as a scenario that portrays someone in the dead of night using Lightyear to decide whether or not to get married or one that depicts a corporate executive wrestling with the jobs and fate of thousands of workers, but it's the kind of situation that can eventually drain a business of a hundred times as much money—if the problem is not successfully resolved—as the cost of a personal computer and a DSS package.

The decision facing Blight was how to choose among a variety of sales and production plans available for managing his company's investment in their two major products, which were being handled in a somewhat haphazard and fragmented way. Viewed from a slightly different angle, Blight was looking for a framework that would enable coordination and communication between sales and production.

MAC-PAC/PC from Arthur Anderson and Co., a decision-modeling package designed to help the top management of a manufacturing company effectively plan company sales and production, had the potential to provide that framework. It took a substantial investment of time and energy to input such factors as lead times, resources and materials, cost and price information, and monthly sales and production plans for each product into the MAC-PAC matrix. Indeed, collecting data from the sales and production departments, organizing it, and keying it into the appropriate parts of the MAC-PAC/PC program constitutes the major time investment in reorienting a company like United Air to the use of DSS software.

However, an immediate benefit was derived from this effort: an effective reorganization of the company's internal information. Some experts argue, in fact, that this is the biggest potential benefit of DSS programs because getting the right information—not analyzing it—is the real thorn in the side of most decision makers. Once MAC-PAC/PC had that information about United Air, it gave Blight a system he could use to help plan the production and sales of his two top-selling products.

For Blight, a major attraction of the program, even before it solved any specific sales and production problems, was that it did provide a useful framework for coordinating the activities of the departments within his company. Not only did MAC-PAC help him transform three loosely related departments into a more smoothly functioning single operation, but the program's ability to manipulate key sales and production factors also helped maintain a consistently high level of interdepartmental coordination and planning over time. Once the program has been fed basic information about any company's product lines, planners within the company can use MAC-PAC/PC to estimate the financial consequences of different decisions they might make in developing monthly production and sales plans for each product line.

The software does not make the final decision about which plan makes most sense for the company in the face of fluctuating market conditions and other factors such as cost and availability of necessary components. But it does encourage and help people in each department maintain consistent and current data to support such decisions. And it allows planners to increase the reliability of their predictions by analyzing key data with greater efficiency. MAC-PAC/PC is specifically designed to help organize the internal information from which sales and production decisions will be made, but it also allows some "what-if" simulations of potential outcomes.

Broader Applications

Other decision-modeling packages have still broader applications—as a negotiating tool, for example. Senior executives of a high-technology firm were looking for a way to better manage financial relationships with suppliers of critical components and subsystems. Determining the optimal trade-off between purchase price and payment terms was their prime concern. Inevitable difficulties in forecasting market prices and seasonal fluctuations in demand added to the overall planning dilemma.

The executives and managers involved in this dilemma were not looking for a software panacea; they were hoping for a tool to clarify the complexities of the situation and identify the critical issues.

IFPS/Personal from Execucom was chosen for several reasons. First, it has the ability to break a problem down into segments rather than treat it as one large model. Second, since it's a menu-driven program with an English-like, nonprocedural language for developing financial models, it avoids direct contact with lower-level programming languages. And third, it's available in both personal computer and mainframe versions.

The mainframe program is called the "Interactive Financial Planning System"—it can be used as both a stand-alone modeling and planning system and as an integrated micro-to-mainframe decision support system that unites the accessibility of personal computing with the power and sophistication of a mainframe. In our IFPS/Personal case study, this combination of personal computing and mainframe computing proved a valuable asset. The personal computer version could be used during actual negotiations with suppliers, while the mainframe version allowed more sophisticated goal-seeking analyses than would have been possible with just a personal computer.

Using IFPS/Personal, a task force of representatives from several different departments built a model that contained 22 variables ranging from unit selling and purchase prices to selling-price erosion rate and purchase-price decline rate. In the process, all of the people involved increased their understanding of the negotiating situation they were entering and got a better feel for the relationship between the various decision-making factors. Once the system was up and running, senior management could refine its negotiating strategy by simulating the results of different negotiated agreements in the face of a variety of market conditions.

Encore from Ferox Microsystems is another program that would fit well with the kind of situation described here. Encore can handle linear-regression applications, a feature not available in the current version of IFPS/Personal, but it has its own brand of programming language (often called a procedural language). Users must master the rules of this language to know in what sequences commands have to be listed to execute properly.

The Confidence Factor from Simple Software Inc. stretches the seams of our two neat categories of DSS programs a bit. But I think it's worth a close look even though it muddies the waters somewhat. The Confidence Factor is aptly subtitled "The decision maker's toolkit." It includes seven easy-to-use, well-documented programs that can be used to evaluate business plans or proposals, develop strategic plans, plan and schedule projects, explore qualitative decision alternatives, optimize your company's resources, maximize profit potential, and simulate business risk situations. The opening page of each module explains the theory behind the program.

The Decision Tree Analysis module helps you determine the effect of a sequence of decisions leading to one of several potential outcomes of a strategic decision by presenting the decision process as a group of choices each having a possible "next" outcome and those outcomes in turn having further possible outcomes. The Best Alternative, Best Course of Action, and Yes/No decision modules are all adaptations of the Kepner-Tregoe technique of using weighted judgment factors. Risk Simulation helps establish the risk factor of a decision by the proven Monte Carlo Simulation technique using a probabilistic model at each step along the way. The Linear Programming module helps optimize resource allocation, while the Project Planning and Scheduling module simplifies the Critical Path Method.

The Final Factor: Reality

If all important personal, professional, and business decisions were made at month-long retreats by people who were freed of all other responsibilities while deciding, it would be easy to recommend regular use of a DSS program just to see what it might yield. But that's not the way of the world. Real people make real decisions by the handful under the pressure of time and often without all the information they would ideally like to have. Then they see how things turn out and make another decision to try to get a bit closer to their goal.

That complex, partly irrational, and time-bound system has somehow kept things moving along for several thousand years and will likely play a continuing role in the decision making of managers and professionals for some time to come. A decision support package, to be useful, must fit into the reality of your situation, not the other way around. One that does fit, however, can be well worth your investment of time, effort, and money—a most useful adjunct to the human brain and gut, still our two main decision support systems. □

Handout 2-3

DECISION SUPPORT SYSTEM METHODOLOGY

I. Microcomputer Decision Support Systems

A. A Weapons Contract Example

1. Background Information

This example demonstrates the use of multi-variate utility analysis within the context of a realistic example. The example provides basic information on various measures of merit from six weapons contractors.

2. The Weapons Contract

The Decision Support System in this case is used to analyze contractor data. Thus a Weapons Contract Award Decision Support System Study is undertaken to provide the decision-maker with sufficient information and analysis for a rational decision. The study and analysis is also used to track a series of agreements on the relative values of the various criteria and how each contractor measures up to the criteria.

II. The Process and Methodology

A. The Decision Process

1. Problem Definition

Defining and stating a problem sets up or initializes the process of study and analysis for solution. Several questions may be asked in this stage such as, "Why not do absolutely nothing?" Doing nothing is a course of action, however, if the problem is not going to go away it must be well defined. Generally there will be compelling reasons which give rise to the need for a decision. Thus, answering this question carefully will record those reasons and add to the credibility of the ensuing analysis.
Several other considerations may add to the quality of the problem statement. Defining boundaries, constraints, costs and assumptions can add structure and better understanding by individuals involved.

2. Statement of Purpose

Finding feasible or possible solutions or courses of action for a given problem requires insight to all aspects of the problem. What is the "real" problem? What are its causes? Once the problem is well defined and stated, the purpose can be stated.

Reprinted with permission from NDU Course 130, National Defense University, Ft. McNair, Washington DC.

3. Criteria Definition

The first step in defining criteria is to select the top level criteria--criteria that can be further broken out into finer elements of discrimination. If there are only a few criteria they may all be first or top level.

4. Criteria Assessment

Assessing criteria is an important step. It is here that many external factors must be considered. What decision-chain led to this point? What is our guidance? What relative assessment will hold up to scrutiny? Which criteria are more important?--How much more important?

At this point we are not overly concerned with the present or currently defined alternatives. More may appear prior to the decision, right? At this stage getting consensus from the individuals involved with the decision is vital. Agreements must be reached on which criteria are more important and by how much. Additionally, some criteria may be specified as absolute--it must be there. What this means is that it will not be assigned a relative value. Must have type criteria may act as filters. They provide boundaries or limit the possible entry. Cost, for example could be broken out in several ways. One criteria might be stated as a must--<u>Cost Limit</u>. <u>Cost must be under $300 million.</u> Another criteria may then be simply <u>cost</u> but is assigned a percentage value of importance relative to other criteria.

5. Alternatives

In this step each alternative, option or course of action is recorded. Each alternative is described in detail with all the critical information. Even if you already know that it may not "pass" some must have filter it may still be a candidate. It could change later. Or, at the next briefing your must have criteria may change, etc.

6. Weighting

At this stage of analysis weights are given to each alternative for each criteria. How well do they stack up? Which alternative meets which criteria best? By how much do the others meet it or not relative to the definition of best?

7. Scoring

Cross-multiplying the weights times the criteria values produces a final score. Any alternative that did not pass a must have criteria is scored zero. Scores are normalized to a %100 so that the top contender achives %100. All others will have some other percentage which will suggest further analysis.

8. Analysis

Who was Murphy anyway? Is he often right? What can you do about it? This section provides the subjective heart of your study. What justifies your criteria values?--your weights?--your scores? What can go wrong? What are the potential problems and their seriousness? If the recommended decision is made how do we prevent potential disasters? What pitfalls may lie ahead?

What about subtle changes to the criteria assessment and/or the weights? Sensitivity analysis must be included in order to examine several "What if...?" type statements. What if some alternative changes specification--some improvement or quality/reliability test failure?

9. Conclusions

No suprises here! No new information! By the time your reader gets to this point it must be almost unneccessary to read further. The conclusions and recommended action must flow directly and logically from the analysis. Absolute clarity with no hedging is critical at this point. The decision is being called for.

B. Contractor Data Content

1. Development Costs

2. Productions Costs

3. Operation and Maintenance Costs

4. Full Operational Capability Date

5. Life Cycle

6. Availability Measures

7. Reliability Measures

8. Accuracy

9. Surge Potential

C. Calculation of Criteria Values

1. Raw Numbers

2. Base One Hundred

3. Criteria Graphical Analysis

D. Calculation of Weights

1. Weight Factors

2. Linear Weight Assessment

E. Final Scoring

1. Raw Scores

2. Normalized Scores

III. Analysis and Conclusions

A. Graphical Analysis

B. Conclusions

Decision Support Systems

Microcomputer
Decision Support
Systems

An Example
Using Framework
for a

WEAPONS CONTRACT

DECISION SUPPORT

SYSTEM

OVERVIEW

Process
Content
Calculation
Decision
Demonstration

THE DECISION PROCESS

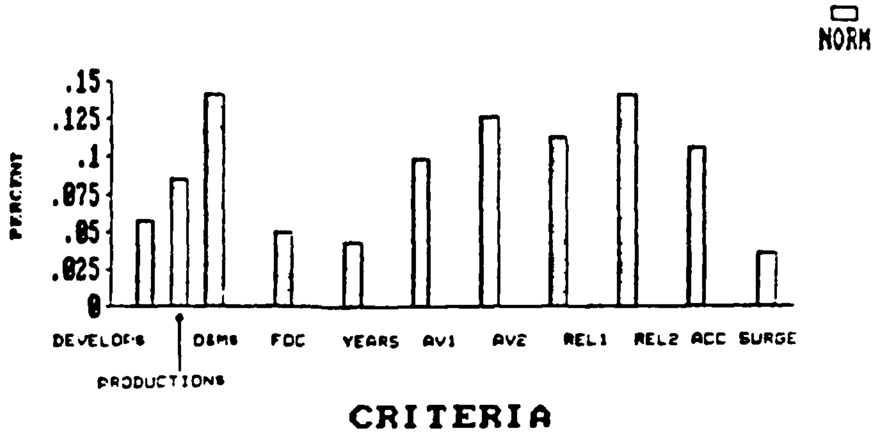
1. Define the Problem
2. State the Purpose
3. Define Criteria
4. Assess Criteria
5. Define Alternatives
6. Weight Alternatives
7. Final Scoring
8. Analysis
9. Conclusions--
   Recommendations

CONTRACTOR DATA

1. Development Costs
2. Production Costs
3. Operation & Maintenance
4. Full Operation Capability Date
5. Life Cycle
6. Availability Measures
7. Reliability Measures
8. Accuracy
9. Surge Potential

CRITERIA	VALUE	%
Develop $	40	5.67
Product $	60	8.51
O&M $	100	14.18
FOC	35	4.96
Years	30	4.26
Avail 1	70	9.93
Avail 2	90	12.77
Rel 1	80	11.35
Rel 2	100	14.18
Accuracy	75	10.64
Surge	25	3.55
TOTALS	705	100%

CRITERIA WEIGHTS



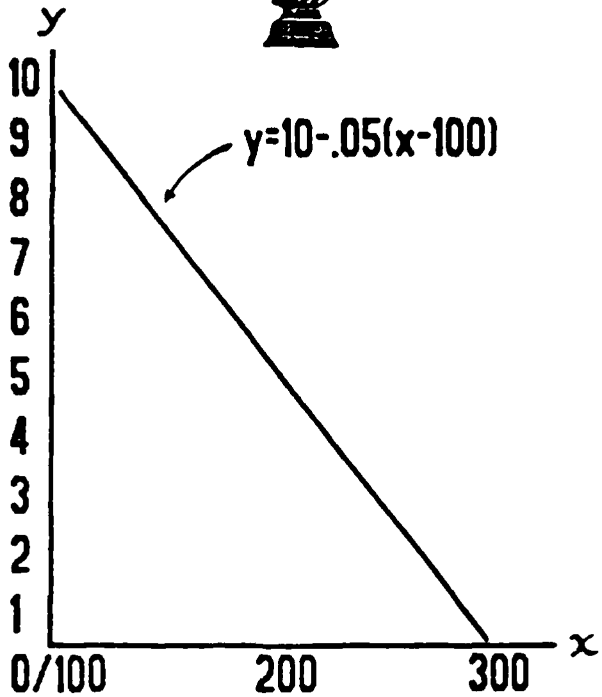
CONTRACTOR WEIGHTING

CO.	PRODUCTION $	WEIGHT
A	150	7.50
B	125	8.75
C	105	9.75
D	165	6.75
E	130	8.50
F	145	7.75

$ in Millions

Weighting Scale: 0 to 10

Linear Weight Assessment

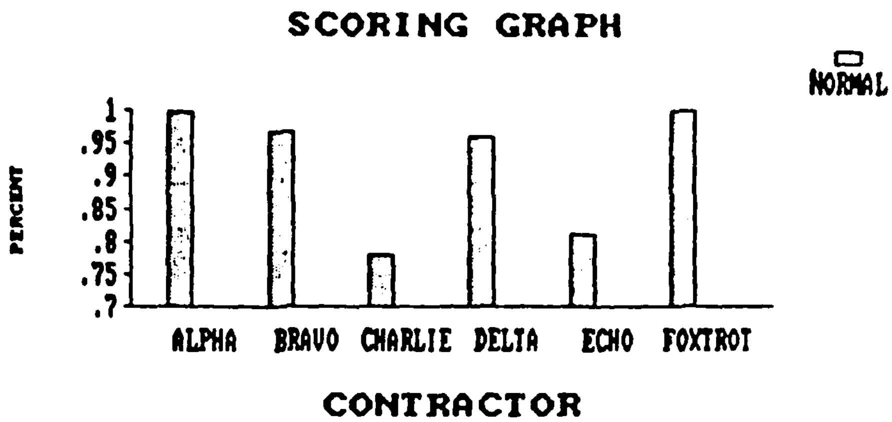


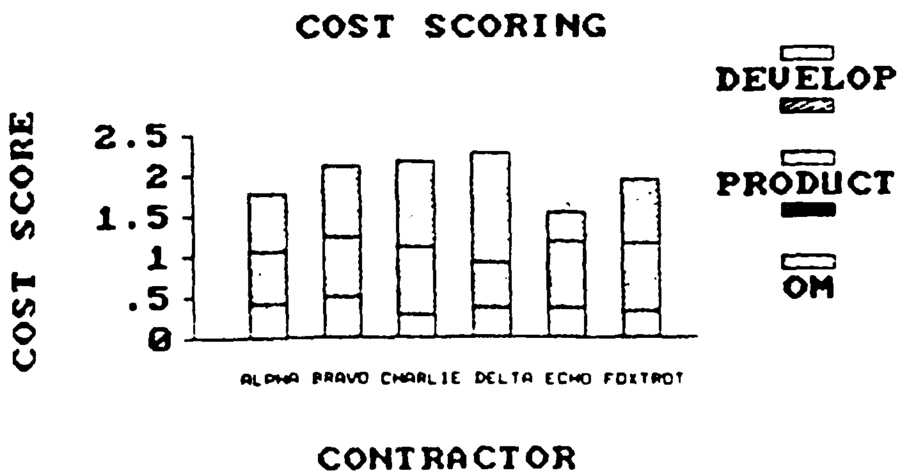
FINAL SCORING

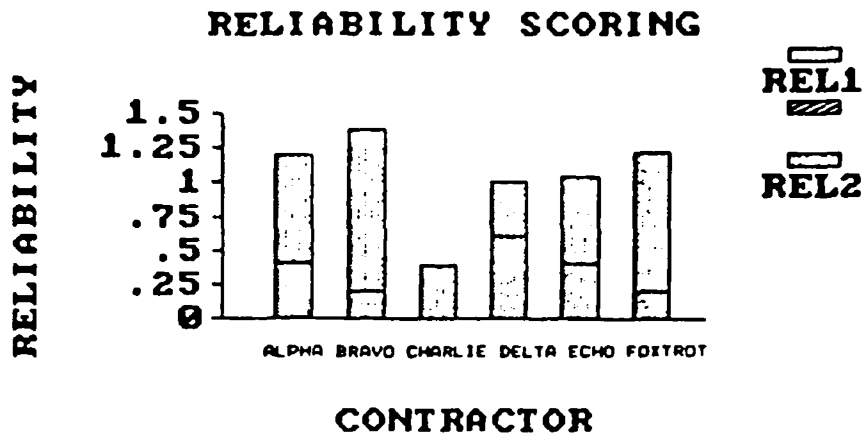
Contractor Score equals:
Sum(Criteria% X Weight)

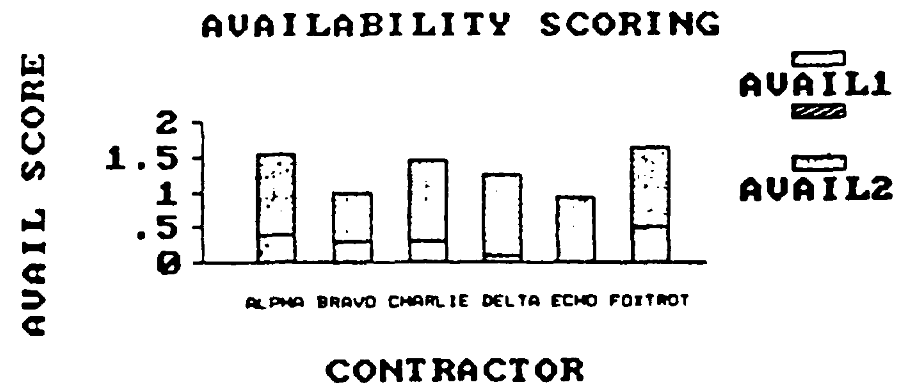
Normalize to 100% by dividing each Score by the Maximum Contractor Score

The "Best" Contractor
Normalized Score
Equals
100%


SCORING GRAPH
NORMAL
PERCENT
1
.95
.9
.85
.8
.75
.7
ALPHA
BRAVO
CHARLIE
DELTA
ECHO
FOXTROT
CONTRACTOR


COST SCORING
DEVELOP
PRODUCT
OM
COST SCORE
2.5
2
1.5
1
.5
0
ALPHA BRAVO CHARLIE DELTA ECHO FOXTROT
CONTRACTOR


RELIABILITY SCORING
RELIABILITY
1.5
1.25
1
.75
.5
.25
0
ALPHA BRAVO CHARLIE DELTA ECHO FOXTROT
CONTRACTOR
REL1
REL2


AVAILABILITY SCORING
AVAIL SCORE
2
1.5
1
.5
0
ALPHA BRAVO CHARLIE DELTA ECHO FOXTROT
CONTRACTOR
AVAIL1
AVAIL2

PROBLEM A SCENARIO

You have decided to buy an air conditioner to cool your family room (500 square feet). You have three concerns about this purchase, first, what capacity the air conditioner must be, next, how efficient will it be to keep the energy cost down, and finally, how much can you afford to pay?

You have determined your cooling need from a US Dept of Energy handout. This handout recommends an air conditioner of 12,000 Btuh to properly cool your 500 square foot family room.

Also, this same handout said the energy efficiency range (EER) for 12,000 Btuh air conditioners were from 5.0 to 10.0. The models with the highest efficient energy rating number use less energy and cost less to operate.

Based on your budget, you have decided not to spend more than $500 for this air conditioner.

On your visit to several local air conditioner dealers, you obtained the following information:

Specifications Table

	Model A	Model B	Model C	Model D	Model E	Model F
Btuh	13,800	14,000	12,800	11,000	11,500	12,000
ERR	6.3	9.9	8.8	9.0	8.7	8.0
Price	$389.99	$509.00	$439.99	$469.00	$469.00	$499.99

Now, using SMART, the weighted criteria model, and instructor assistance, make your decision in buying one of the above air conditioners.

PROBLEM A SOLUTION

PROBLEM

You have decided to buy an air conditioner to cool your family room (500 square feet). You have three concerns about this purchase, first, what capacity the air conditioner must be, next, how efficient will it be to keep the energy cost down, and finally, how much can you afford to pay?

You have determined your cooling need from a US Dept of Energy handout. This handout recommends an air conditioner of 12,000 Btuh to properly cool your 500 square foot family room.

Also, this same handout indicates that the energy efficiency ranges (EER) for 12,000 Btuh air conditioners are from 5.0 to 10.0. The models with the highest efficient energy rating number use less energy and cost less to operate.

Based on your budget, you have decided not to spend more than $500 for this air conditioner.

On your visit to several local air conditioner dealers, you obtained the following information:

SPECIFICATIONS TABLE

Model	A	B	C	D	E	F
Btuh	13,800	14,000	12,800	11,000	11,500	12,000
ERR	6.3	9.9	8.8	9.0	8.7	8.0
Price	$389.99	$509.00	$439.99	$469.00	$469.00	$499.99

SOLUTION

Now, let us lay out the solution. The first decisions are in the area of criteria establishment and value assignments. We have already established the criteria by virtue of our data collection. We might consider other factors such as ease of installation, brand name experience, and reliability, but the three criteria shown in the SPECIFICATIONS TABLE above and repeated in the VALUES TABLE below are the ones selected.

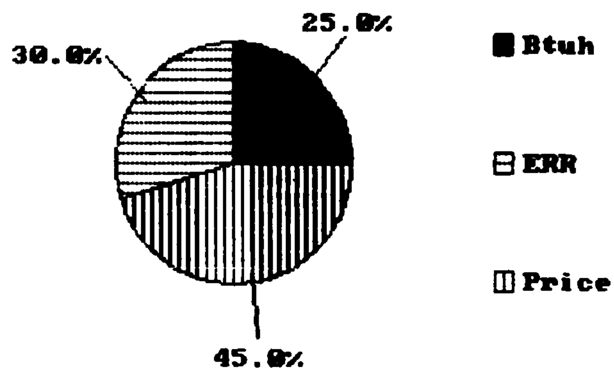
As to weighting, we need to prioritize and assign relative values to those criteria. Then based on those assigned values, a percentage calculation is developed for later use in scoring our solution. In this example, we have determined that price is our most important factor, followed by Btuh and ERR. Remember that in a sensitivity analysis, changing these priorities and/or assigned values has a direct effect in overall scoring.

VALUE TABLE

Criteria	Value	%	Cum %
Btuh	25	25.00%	25.00%
ERR	30	30.00%	55.00%
Price	45	45.00%	100.00%
Total	100		

Another way of looking at this data is with a pie chart projection to show the relative parts of our decision.

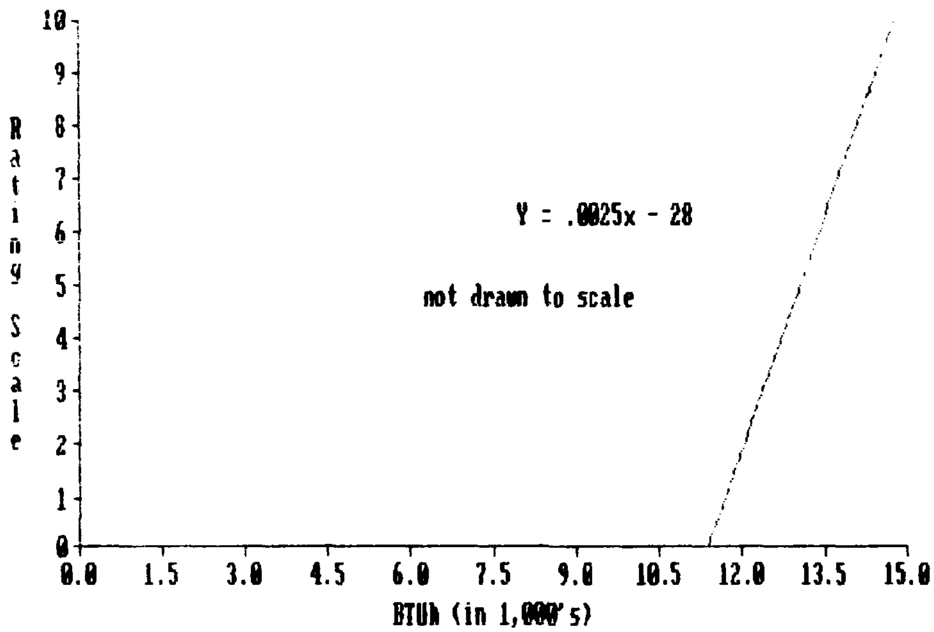
PIE CHART VALUES



LINEAR GRAPH

The next part of the solution is fit each of the air conditioner systems to a linear graph. Each criteria has its own graph. Assumptions are to make all graphs with a Y-axis from 0 (worst) to 10 (best) and an X-axis depicting best and worst values from left to right. For Btuh, we decided that 11,000 is the worst value and 15,000 is the best possible value for Btuh. In graphing Btuh we get this linear graph and equation. All six Buth values fit this graph. for example, entering with 14,000 Btuh for Model B yields a value of 7.50 on the Y-Axis. This data for the full spectrum of criteria and systems is shown in the **WEIGHT TABLE** below.

LINEAR GRAPH - BTUH'S



RANGE TABLE

Criteria	Best	Worst
Btuh	15,000	11,000
ERR	10	5
Price	350	500

SCORING MATRIX

The next step is to set up a scoring matrix to show all of the air conditioner attributes and their scores. All the scores were figured by using the linear function. This allows each criteria for each system to be arrayed on the 0-10 scale (Y-Axis) and reflects the above linear graphs in tabular form.

WEIGHT TABLE

Criteria	y = ax + b					
Btuh	7.00	7.50	4.50	0.00	1.25	2.50
ERR	2.60	9.80	7.60	8.00	7.40	6.00
Price	7.33	-0.60	4.00	2.07	2.07	0.00

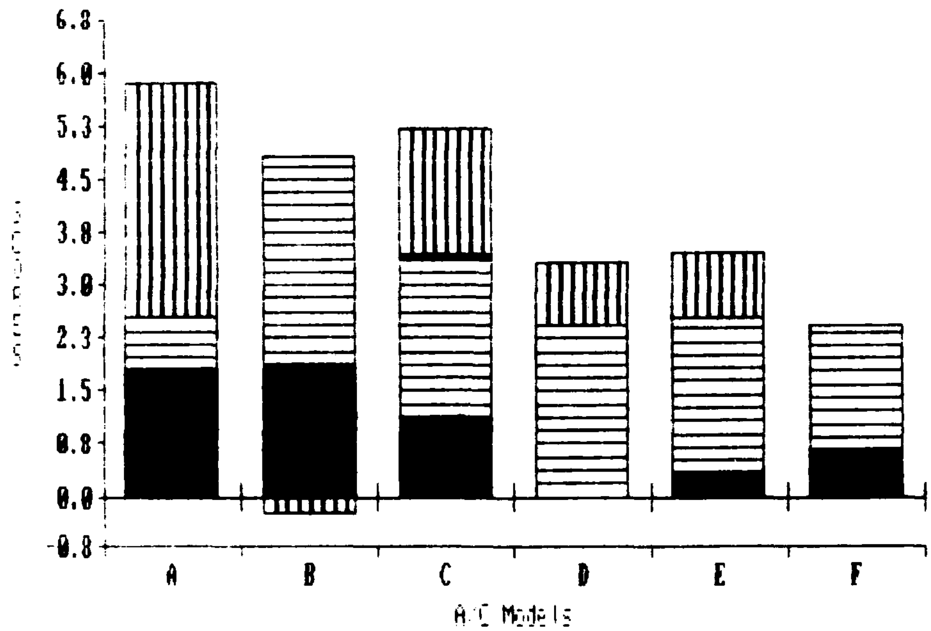
FINAL SCORING

The final scores are shown in the following chart. The scores are normalized to 100% and represent the product of **VALUE** times **WEIGHT**. The scores show that Model A scores the highest. But, the scores for Model B and Model C are fairly close. Note that Model B has better scores for Btuh and ERR. Sensitivity analysis might suggest that you reconsider your **VALUE** for Price.

SCORING TABLE

Criteria	A	B	C	D	E	F
Btuh	1.75	1.88	1.13	0.00	0.31	0.63
EPR	0.78	2.94	2.28	2.40	2.22	1.80
Price	3.30	-0.27	1.80	0.93	0.93	0.00
Totals	5.83	4.55	5.21	3.33	3.46	2.43
Total*10	58.30	45.45	52.05	33.30	34.63	24.25

The following graph shows the combined scores from the **SCORING TABLE.**



SENSITIVITY ANALYSIS

Since our scores are fairly close on models A, B, and C, we should re-examine our decision by sensitivity analysis. Suppose we decided that our budget could really stand for a price of $550.00. What happens to our SCORING TABLE then?

NEW SCORING TABLE

Criteria	A	B	C	D	E	F
Btuh	1.75	1.88	1.13	0.00	0.31	0.63
ERR	0.78	2.94	2.28	2.40	2.22	1.80
Price	3.60	0.92	2.48	1.82	1.82	1.13
Totals	6.13	5.74	5.88	4.22	4.36	3.55
Total*10	61.30	57.38	58.80	42.23	43.55	35.50

This shows that price is a large factor in our decision. This largely relates to the relatively wide range in the price factor ($350 - $550 in this second example and $350 - $500 in the original example). We still have not differentiated a choice, and, in fact, have made the three systems even closer together.

Another aspect to consider is changing values. We now decide that long-term energy costs are more important than price. This makes sense because the system costs are very close to one another and we are likely to keep this air conditioner for a long time (several years). By reshuffling the values to 25, 45, and 30 for Btuh, ERR, and price, respectively, we can get the following SCORING TABLE. Price still reflects the original $500.00 as a worst case.

NEW SCORING TABLE

Criteria	A	B	C	D	E	F
Btuh	1.75	1.88	1.13	0.00	0.31	0.63
ERR	1.17	4.41	3.42	3.60	3.33	2.70
Price	2.20	-0.18	1.20	0.62	0.62	0.00
Totals	5.12	6.11	5.75	4.22	4.26	3.33
Total*10	51.20	61.05	57.45	42.20	42.63	33.25

Sensitivity analysis allows us to see how sensitive weights and values are by showing "what if?" scenarios. By virtue of this capability, we can see the orginal choices may be inappropriate to a given situation. In any case, we have to make a decision.

FINAL SOLUTION after SENSITIVITY ANALYSIS

If we consider price to be our major factor then we would probably pick Model A per the original SCORING TABLE. If ERR is the prime factor in our decision, we would probably select Model B per the last NEW SCORING TABLE. If we like a blend of price and ERR, Model C is a good choice. In any case, the ultimate decision is up to you. The computer model has allowed you to "game" it and examine our decision through "what if?" reiterations. Many times a clear-cut decision will not pop out, but the choices can be narrowed as this example has shown. Remember, a DSS is to assist you in a decision, not to make it for you.

INSTRUCTOR NOTE

This solution follows the general format used in the format used in the "Micro Decision Support Systems" course taught at the National Defense University, Ft McNair, Washington D.C. (5:121-131)

PROBLEM B SCENARIO

You are the project officer for a computer buy for the 357th Fighter Weapons Wing. You have been allocated $20,000 to purchase computer systems for squadron-level use. The systems will all be used in a stand-alone configuration for various administrative and operational purposes.

After exhaustive personal research, you have reached some preliminary conclusions. You need at least six (6) systems, and that a minimum price is $500 per system. Also, since the Air Force is heavily into IBM-compatible systems, you believe this is probably the way to go. However, you have not ruled out other systems.

You are also concerned about such factors as memory, reliability, speed, type of microprocessor, and other factors.

All systems come with printers, monitors, and system software, so you are not going to consider those factors. Other features are as noted in the table below. Now to clarify some criteria. For speed, 8 MHz is approximately twice as fast as 4.7 MHz. System D is the only one with a third generation chip, the 80286, and, in your view, it is at least twice as valuable as any second generation chip. *Reliability from your research is* given on a scale from 1 to 10 with 10 being the best. The following table gives the characteristics of the various systems:

SPECIFICATIONS TABLE

Criteria	System A	System B	System C	System D	System E	System F
Compatability	IBM	IBM	Apple	IBM	IBM	IBM
Microchip	8088	8086	6502	80286	8088	8086
Speed	4.7 MHz	8 MHz	4.7 MHz	8 MHz	6 MHz	8 MHz
RAM Memory	256K	640K	128K	640K	512K	640K
Floppy Disk	1-360K	2-360K	1-143K	1-360K	2-360K	1-360K
Hard Disk	No	No	No	1-20mb	1-20mb	1-20mb
Reliability	8	8	9	8	9	7
Price	$999	$1149	$500	$1850	$1699	$1249

Additional guidance follows giving you the best and worst values available to you in microcomputer systems.

Criteria	Best	Worst
RAM Memorv	720K	128K
Floppy Disk	720K	143K
Hard Disk	20M	0M
Speed	12MHz	4.7Mhz

Using the weighted criteria decision model, the SMART system, and the given data, decide which system to purchase. Your decision is to be included in an integrated final report similar to the one given to you for Problem A. Follow the guidance and clues given above.

PROBLEM B SOLUTION

PROBLEM

You are the project officer for a computer buy for the 357th Fighter Weapons Wing. You have been allocated $20,000 to purchase computer systems for squadron-level use. The systems will all be used in a stand-alone configuration for various administrative and operational purposes.

After exhaustive personal research, you have reached some preliminary conclusions. You need at least six (6) systems, and that a minimum price is $500 per system. Also, since the Air Force is heavily into IBM-compatible systems, you believe this is probably the way to go. However, you have not ruled out other systems.

You are also concerned about such factors as memory, reliability, speed, type of microprocessor, and other factors.

All systems come with printers, monitors, and system software, so you are not going to consider those factors. Other features are as noted in the table below. Now to clarify some criteria. For speed, 8 MHz is approximately twice as fast as 4.7 MHz. System D is the only one with a third generation chip, the 80286, and, in your view, it is at least twice as valuable as any second generation chip. Reliability from your research is given on a scale from 1 to 10 with 10 being the best. The following table gives the characteristics of the various systems:

SPECIFICATIONS TABLE

Criteria	System A	System B	System C	System D	System E	System F
Compatability	IBM	IBM	Apple	IBM	IBM	IBM
Microchip	8088	8086	6502	80286	8088	8086
Speed	4.7 MHz	8 MHz	4.7 MHz	8 MHz	6 MHz	8 MHz
RAM Memory	256K	640K	128K	640K	512K	640K
Floppy Disk	1-360K	2-360K	1-143K	1-360K	2-360K	1-360K
Hard Disk	No	No	No	1-20mb	1-20mb	1-20mb
Reliability	8	8	9	8	9	7
Price	$999	$1149	$500	$1850	$1699	$1249

SOLUTION

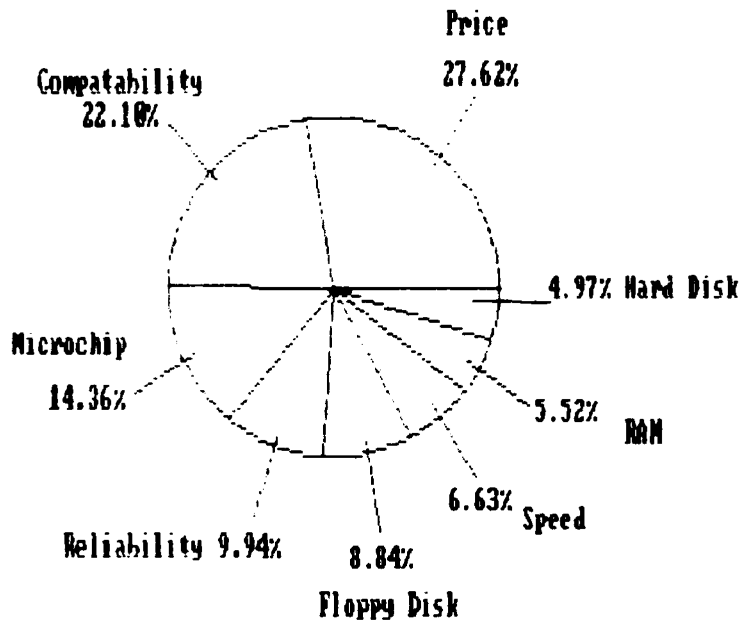
The first decisions are in the area of criteria establishment and value assignments. The criteria selected are in the above SPECIFICATIONS TABLE. As to weighting, we need to prioritize and assign relative values to those criteria. Then based on those assigned values, a percentage calculation is developed for later use in scoring our solution. In this example, we have determined that price is our most important factor (VALUE TABLE below). Your solution may be different based on your analysis.

VALUE TABLE

Criteria	Value	Pct	Cum Pct
Price	250	27.62%	27.62%
Compatability	200	22.10%	49.72%
Microprocessor	130	14.36%	64.09%
Reliability	90	9.94%	74.03%
Floppy Disk	80	8.84%	82.87%
Speed	60	6.63%	89.50%
RAM Memory	50	5.52%	95.03%
Hard Disk	45	4.97%	100.00%
TOTAL	905		

Another way of looking at this data is with a pie chart projection to show the relative parts of our decision.

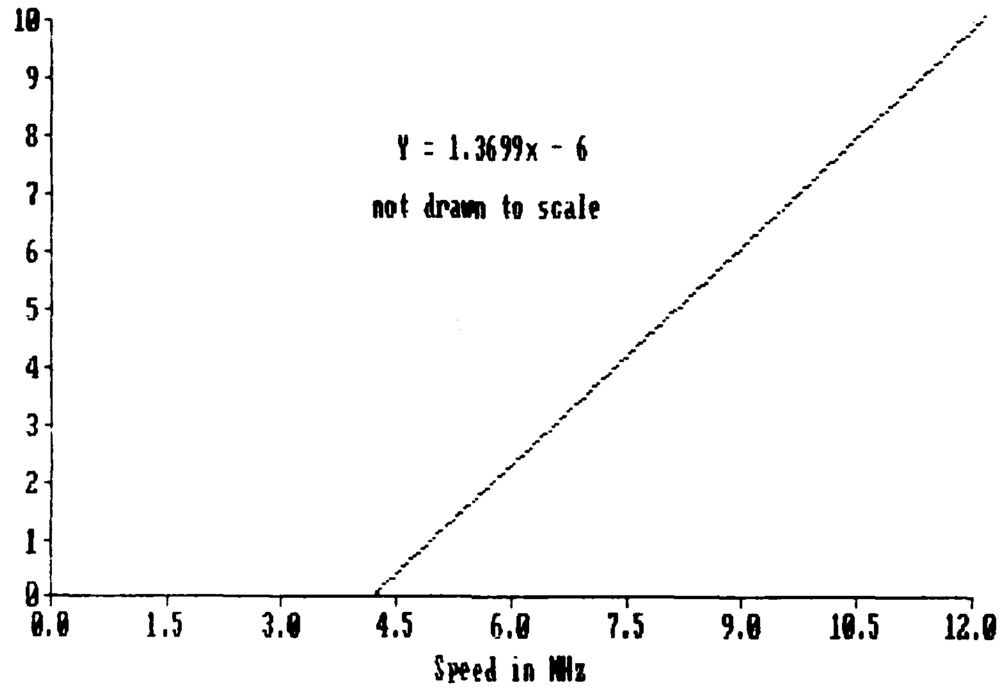
PIE CHART VALUE



LINEAR GRAPH

The next part of the solution is to fit each of the criteria to its own linear graph. Assumptions are to make all graphs with a Y-axis from 0 (worst) to 10 (best) and an X-axis depicting best and worst values from left to right. For speed, we decided that 4.7 is the worst value and 12 is the best possible value (as given in the scenario). All six speed values fit this graph. For example, entering with a speed of 8Mhz yields a value of 6.67 on the Y-axis. This data for the full spectrum of criteria and systems is shown in the **WEIGHT TABLE on the next page.**

LINEAR GRAPH - SPEED



RANGE TABLE

Criteria		Best	Worst
Price	$	500	3333
Compatability	10=y,0=N	10	0
Microprocessor	Arbitrary	4	0
Reliability	Scale 0-10	10	0
Floppy Disk	K of RAM	720	143
Speed	MHz	12	4.7
RAM Memory	K of RAM	640	128
Hard Disk	M of RAM	20	0

SCORING MATRIX

The next step is to set up a scoring matrix to show all of the computer system criteria and their scores. All the scores were figured by using the linear function. This allows each criteria for each system to be arrayed on the 0-10 (Y-axis) and reflects the above linear graphs in tabular form.

WEIGHT TABLE (y = ax + b)

Criteria	System A	System B	System C	System D	System E	System F
Price	8.24	7.71	10.00	5.23	5.77	7.36
Compatability	10.00	10.00	0.00	10.00	10.00	10.00
Microprocessor	5.00	5.00	5.00	10.00	5.00	5.00
Reliabilit	8.00	8.00	9.00	8.00	9.00	7.00
Floppy Disk	3.76	10.00	0.00	3.76	10.00	3.76
Speed	0.00	0.00	0.00	4.52	1.78	4.52
RAM Memory	2.50	10.00	0.00	10.00	10.00	10.00
Hard Disk	0.00	0.00	0.00	10.00	10.00	10.00

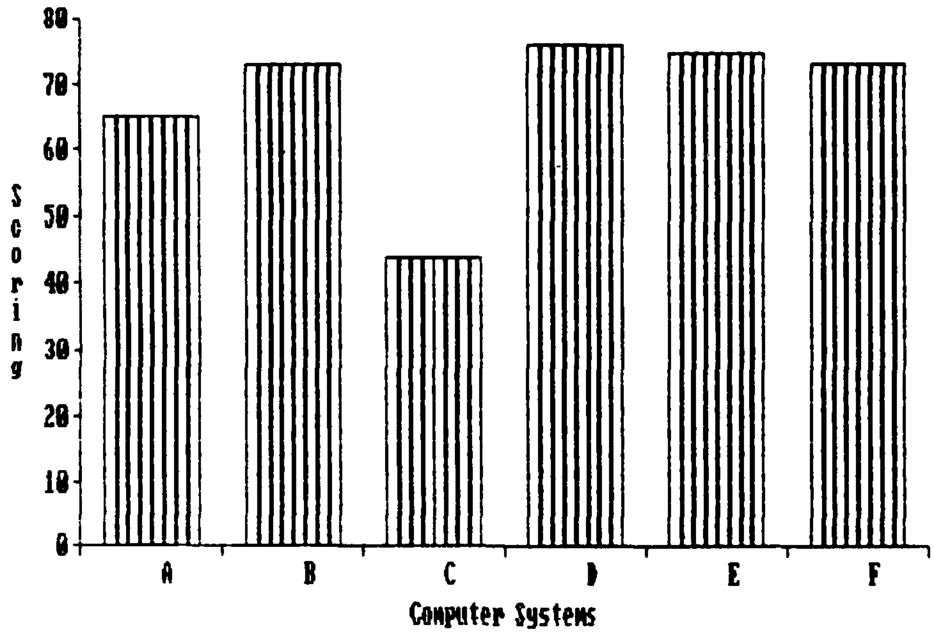
FINAL SCORING

The final scores are shown in the following chart. The scores are normalized to 100 % and represent the product of VALUE times WEIGHT.

SCORING TABLE (VALUES times WEIGHTS)

Criteria	System A	System B	System C	System D	System E	System F
Price	2.28	2.13	2.76	1.45	1.59	2.03
Compatability	2.21	2.21	0.00	2.21	2.21	2.21
Microprocessor	0.72	0.72	0.72	1.44	0.72	0.72
Reliability	0.80	0.80	0.90	0.80	0.90	0.70
Floppy Disk	0.33	0.88	0.00	0.33	0.88	0.33
Speed	0.00	0.00	0.00	0.30	0.12	0.30
RAM Memory	0.14	0.55	0.00	0.55	0.55	0.55
Hard Disk	0.00	0.00	0.00	0.50	0.50	0.50
TOTALS	6.47	7.29	4.38	7.57	7.47	7.34
TOTALS X 10	64.70	72.90	43.76	75.70	74.68	73.38

The following graph depicts the combined scores from the **SCORING TABLE.**



The scores show that System D is rated the highest, but Systems B, E, and F are close. Your solution could stop here by selecting any of these four systems, however, some sensitivity analysis is in order.

SENSITIVITY ANALYSIS

Since the scores are so close on the four systems (B, D, E, and F), we will re-examine our decision. It appears that our **RANGE TABLE** is okay, so the place to look is in the **VALUES TABLE** and see what happens if we shift some of them. Suppose we decide that a Hard Disk is an important facet of our system. When we up the **VALUE** of this criteria from 45 to 150, the following **SCORING TABLE** results. Now System B drops from consideration.

NEW SCORING TABLE

Criteria	System A	System B	System C	System D	System E	System F
Price	2.04	1.91	2.48	1.30	1.43	1.82
Compatability	1.98	1.98	0.00	1.98	1.98	1.98
Microprocessor	0.64	0.64	0.64	1.29	0.64	0.64
Reliability	0.71	0.71	0.80	0.71	0.80	0.62
Floppy Disk	0.30	0.79	0.00	0.30	0.79	0.30
Speed	0.00	0.00	0.00	0.27	0.11	0.27
RAM Memory	0.12	0.50	0.00	0.50	0.50	0.50
Hard Disk	0.00	0.00	0.00	1.49	1.49	1.49
TOTALS	5.80	6.53	3.92	7.82	7.73	7.61
TOTALS X 10	57.98	65.32	39.21	78.23	77.31	76.15

Another aspect to consider might be the Microchip. Is it more important to us to have the third generation chip? We have assigned a 2:1 factor in the RANGE TABLE already, but if we up the Microchip value from 130 to 200, we get the following SCORING TABLE.

NEW SCORING TABLE

Criteria	System A	System B	System C	System D	System E	System F
Price	1.91	1.78	2.31	1.21	1.34	1.70
Compatability	1.85	1.85	0.00	1.85	1.85	1.85
Microprocessor	0.93	0.93	0.93	1.85	0.93	0.93
Reliability	0.67	0.67	0.75	0.67	0.75	0.58
Floppy Disk	0.28	0.74	0.00	0.28	0.74	0.28
Speed	0.00	0.00	0.00	0.25	0.10	0.25
RAM Memory	0.12	0.46	0.00	0.46	0.46	0.46
Hard Disk	0.00	0.00	0.00	1.39	1.39	1.39
TOTALS	5.75	6.43	3.99	7.96	7.55	7.45
TOTALS X 10	57.46	64.33	39.91	79.64	75.54	74.45

We now could be fairly sure in selecting System D. By doing sensitivity analysis, we have been able to "what if?" our situation and second-guess the decision before committing ourselves or our money. One final thought. Your decision may not be the same as this one, but as long as you can live with your VALUES and resultant SCORING, it's probably okay. You also might consider new data that comes in prior to disbursing your funds. Would your decision change if your budget was now only $15,000, or your commander decided he needs at least eight systems? All you have to do is re-enter your spreadsheet, input the new numbers, and recalculate the SCORING TABLE.

INSTRUCTOR NOTE

This solution follows the general format used in the "Micro Decision Support Systems" course taught at the National Defense University, Ft McNair, Washington, D.C. (5:121-130)

APPENDIX D

SUPPLEMENTAL INSTRUCTOR BIBLIOGRAPHY

BIBLIOGRAPHY

Articles and Periodicals

1. Spezzo, Charles. "Decision Support Software." Popular Computing. (October 1985) pp 56-61+

Books

2. Bodily, Samuel E. Modern Decision Making. New York: McGraw-Hill, 1985

3. Moody, Peter E. Decision Making. New York: McGraw-Hill, 1983

4. Schwartz, Andrew N. Using SMART. Indianapolis IN: Que Corporation, 1986.

Official Documents

5. National Defense University. NDU Course 130. Course materials used at National Defense University, Fort McNair, Washington DC. 1986.

END
DATED
FILM
8-88
DTIC